PUBLISHED QUARTERLY)

Journal of the Council for Scientific and Industrial Research.

Vol. 4. AUGUST, 1931. No. 3.

Australian Pastoral Research Trust—Empire Marketing Board Investigations.

1. Introduction.

A short note regarding the events leading up to the formation of the Australian Pastoralists Research Trust and regarding the way in which the work of the Trust is being helped by contributions from the Empire Marketing Board was given in a previous issue (see Vol. 3, November, 1930, p. 233). Briefly, the Board has agreed to contribute up to £3,000 per annum on a £1 for £1 basis over a period of five years. The Trust has already taken advantage of this offer to the extent of £2,000 per annum, but soon hopes to be in a position to accept the remaining £1,000 per annum.

The Council for Scientific and Industrial Research is also co-operating and is providing the necessary supervision and much of the necessary staff and laboratory facilities. It is assisted in this supervision by a committee known as the Advisory Committee on Pastoral Problems and on which the Trust is represented. This committee approves of the investigations to be carried out, reviews the estimated costs, &c.

At its first meeting held at the end of September, 1930, the Committee approved of investigations in the general fields of (i) the nutrition of sheep and (ii) the health of sheep. This work is discussed in detail below.

2. Nutritional Investigations.

The investigations approved on the nutritional side were to consist of studies of (*a*) drought feeding, and (*b*) phosphorus deficiencies.

Drought Feeding.—The objects of the drought feeding work are to develop the most economic formulae for fodders intended for use in times of drought, with due attention to the varieties of fodders likely to be available in the different localities concerned.

Like all other animals, the sheep requires for the maintenance of life two different types of material in its food, namely (i) starchy materials or fats and (ii) proteins. Before the most economic drought formulae can be devised, it is necessary to know, firstly, the minimum amounts of starchy materials and of proteins required for the mere maintenance of life; and, secondly, the quantities of these materials in

the different drought fodders—silage, grains, fodder bushes, &c.—that might be available in the different districts concerned. For instance, it would be possible to say that just so much of this material mixed with just so much of that would be sufficient for the animal; in other words, the minimum amount of money that would take a sheep through a period of drought. Without the above information, any fodder that might be given would in all probability be deficient in either starch or in protein and thus unsuitable; or, on the other hand, it might contain an excess of one of the materials, and thus be needlessly wasteful.

At the present time, comparatively little is known of the minimum amounts of starchy materials necessary to maintain life in the sheep, and still less is known regarding the protein requirements. Moreover, these amounts will differ in sheep of different breeds, of different ages, with different histories regarding previous conditions of feeding, &c.

There is the further consideration that the particular variety of protein fed is of great importance. Proteins differ very considerably in their value to the sheep. In particular, the variety containing cystine is of outstanding value to the animal as it is necessary for the formation of wool. If, therefore, a drought fodder be so chosen that it contains a high percentage of cystine and the minimum content of starchy materials necessary to maintain life, it is quite possible that the wool grown may entirely cover the cost of the supplementary fodders.

Work on this problem is in progress in Adelaide. Some of the special equipment necessary has been designed and purchased, and the preliminary experiments are under way. It is proposed that the investigations will be carried out in a small building to be erected beside the laboratory of the Division of Animal Nutrition in Adelaide. The capital cost of the building (£1,000) has been provided by the Rural Credits Fund of the Commonwealth Bank.

Phosphorus Deficiencies.—Throughout large pastoral areas of Australia the phosphorus content of the soils is low. This is reflected in a lack of adequate growth of the local sheep, in deficient development of their bones, and in other ways. In some places the deficiency of phosphorus is so acute that it is quite impossible to maintain sheep on the areas for long periods. To sum up, there is no doubt that phosphorus deficiencies in Australia limit the carrying capacity of large areas of what would otherwise be excellent grazing country.

An obvious way of overcoming the trouble is by adding phosphorus containing materials to the diet of the sheep either by top-dressing or by licks. The particular form of material so added, however, exerts a very important effect, for different materials containing phosphorus have quite different solubilities in the digestive organs of the animal and thus are absorbed to different degrees. The usual form of phosphorus bearing material—rock phosphate—is, in fact, rather insoluble, and there are indications that other materials could be used with much better effect. Then, too, the presence of other mineral bodies, e.g., lime, has an important effect in reducing or increasing the solubility of the phosphorus in the digestive organs. Lime, for instance, reduces this solubility, and thus a diet rich in lime is unsuitable in phosphorus deficient areas. Due attention to these other mineral bodies is thus necessary. Experimental work aimed at overcoming the

trouble in the most economical way, i.e., a determination of which of the several available phosphorus containing materials would be the cheapest to use for a particular result, &c., is about to begin.

About one square mile of an area on Kangaroo Island, where a severe phosphorus deficiency exists in parts, has been kindly lent by the owners, and has been divided into a number of paddocks for small experimental flocks. These last will also be lent in the main by the owners concerned. The different groups are being given different forms of phosphorus, and the effects will be noted and also measured by weighing the sheep at intervals.

Experiments carried out to date have demonstrated that the troubles due to the phosphorus deficiency are unaffected by licks of common salt or of iron salts, but that they are overcome by licks of dicalcic phosphate (other phosphatic materials are also under test), and further, that the feeding of small quantities of yeast in addition results in a considerable improvement in the animals both as regards their condition and their wool.

3. Animal Health Investigations.

The investigations approved by the Advisory Committee on the animal health side consist of studies of—

(*a*) Black disease of sheep.
(*b*) Caseous lymphadenitis (cheesy glands) of sheep.
(*c*) Foot rot.
(*d*) Pizzle disease.
(*e*) Infertility in sheep.
(*f*) Internal parasites (worms) of sheep.

Black Disease.—The object of this work is to investigate the effects of vaccinating large numbers of sheep with the vaccine recently evolved by Dr. Turner, and thus to demonstrate the value of that material to a greater extent than has been done in the past.

With the co-operation of the State Department of Agriculture, sheep to the number of 45,000 were vaccinated last season in Victoria. About 15,000 were similarly treated in New South Wales, making a total of 60,000. This programme entailed the preparation of over 160 gallons of vaccine—a very large amount considering the resources of the laboratory where it was made (the Veterinary Research Institute, Parkville)—and the carrying out of over 120,000 inoculations in the field. Each of the owners of the vaccinated sheep has been supplied with printed monthly return forms which are sent in to the investigators from time to time, and as a result of which an estimate of the value of vaccination will be made.

To date the results in Victoria are good, but in New South Wales the problem has been complicated by a particularly heavy infestation of the sheep by flukes. Evidence has also come to hand suggesting the necessity for the incorporation of New South Wales strains of the causal organism in vaccines intended for use in that State.

Caseous Lymphadenitis.—The object of this work is to investigate the preventive measures recommended by a conference of Australian veterinarians which met last year (see this *Journal,* Vol, 3, August, 1930, p. 148). Briefly, these measures were based on the belief that the trouble is due to the animals being infected during shearing

operations with the bacillus giving rise to the disease. During shearing it is particularly easy for the various cuts an animal receives to become contaminated with infected pus from other animals. Further, in view of the fact that it has been found that the percentage of infection in any flock increases with age, it was recommended that the lambs and young sheep should be shorn first in order that the shears might be kept freer from contamination than would be the case if the older sheep, many of which have broken ulcers on their skins, were shorn first.

Experiments have been carried out on a large and specially selected property in Victoria. Four hundred and thirteen lambs of from five to six months old were taken and divided into three groups as follows:—

Group A.—100 lambs were shorn and eventually inspected after slaughter at the abattoirs. During shearing, the shears were deliberately infected by pus obtained from discharging sores at every tenth lamb. The first six groups of ten lambs were serially numbered in order to see later whether the shears tended automatically to lose their infection during the process of shearing.

Group B.—120 lambs were shorn and eventually inspected. In this case the shears were cleaned by scrubbing with a stiff brush in a 1 per cent. solution of sodium hypochlorite. The cleaning process was repeated at the end of each batch of 30 lambs. The shearers were also equipped with special water-proofed pants which were washed down with a solution of lysol before commencing and after each thirtieth sheep.

Group C.—142 lambs were shorn and eventually inspected. They were deliberately infected in the same manner as in Group A, the shears being re-contaminated at every tenth lamb. As soon as possible after shearing, the lambs were thoroughly dipped in Cooper's Milk Oil Fluid in the concentration recommended for ordinary parasiticidal purposes.

Controls.—Over 1,000 additional lambs in the flock were shorn in the ordinary way with no attempt to produce or avoid infection.

Vaccine Experiments.—305 lambs (of which 262 (Group D) had been marked a few days before, and 43 (Group E) were unmarked) were vaccinated with a vaccine developed by Dr. Lionel Bull of the Pathological Laboratory at the Adelaide Hospital. They were at the time two months old and, of course, unshorn. Thirty-four days later they were again vaccinated. Two months later they were shorn in the ordinary way amongst a batch of ewes, amongst which there were "discharging" cases of caseous lymphadenitis.

The following results were obtained:—

Group A.—(Shears deliberately infected)—14 per cent. infection.
Group B.—(Shears disinfected)—7.3 per cent. infection.
Group C.—(Shears deliberately infected, but lambs dipped after shearing)—12 per cent. infection.
Group D.—Lambs vaccinated subsequent to marking—3.9 per cent. infection.
Group E.—Lambs vaccinated before marking—no infection as yet.
Controls.—20 per cent. infection.

The above experiments are a further indication that the incidence of caseous lymphadenitis may be practically halved by attending to the disinfection of the shears and to other hygienic measures. The experiment has also failed to demonstrate that dipping off shears (at least in the dipping fluid specified) has any value as a preventive of caseous lymphadenitis. This confirms laboratory tests of a number of ordinary antiseptics and disinfectants when tested as to their efficacy in sterilizing pus or caseous material from infected glands.

Finally, a statistical investigation into the incidence of caseous lymphadenitis as affected by age, breed, sex, district, method of shearing, and other factors, has been carried out, and has given further evidence in support of the hypothesis that the main means of entry of the organism causing the trouble is through wounds obtained during shearing and particularly shearing by machines.

Foot Rot.—A series of experimental pens for sheep have now been erected at the Melbourne Zoological Gardens, and work has been commenced on the first part of the problem, namely, to determine exactly how the disease is transmitted. Very bad cases of foot rot have been kept in close confinement with healthy sheep, and made to stand for six hours per day in a small shallow pool of mud and water. Even after eight or nine weeks, however, and after infecting the feet with contagious pustular skin disease in order to provide an opening for an infective agent, no case of the transmission of foot rot has occurred. In addition, sheep at the laboratory have had canvas boots filled with water fixed to one or more feet for eight to nine weeks, either alone or with scraps of horn or with pus from bad cases of foot rot, but in no case has infection occurred.

However, more recent transmission experiments carried out on pasture during the recent rains have been successful, the explanation being that in the latter case there was a more complete maceration of the skin and horn probably together with the factor of mechanical abrasion due to long grass.

In the cases examined to date, the presence of *B. necrophorus* has been constantly determined, together with the less regular occurrence of several other organisms. These findings agree with those of the Bureau of Animal Industry, U.S. Department of Agriculture. A close watch has been kept for the so-called *Treponema podovis* reported in 1928 by French workers as the cause of foot rot. Only in one case, a particularly severe form, were large numbers of organisms resembling it seen, although even in this case the *B. necrophorus* was also present. Small numbers of spirochaetes and leptospira have been seen in many cases, but their etiological significance is doubtful. No evidence in support of the Italian school's claims that *B. coli* is the causal organism has been obtained.

At present a small flock, including both fine and coarse woolled sheep, is being kept amongst an infected flock in the field, and a constant source of early cases for study is thus being maintained. In these cases the incubation period was about a fortnight.

Pizzle Disease.—Investigations have been carried out upon affected sheep from three districts, viz., Wormbeete, Werribee, and Murrumbeet, and representative cases have been studied in the laboratories at the Veterinary Institute, Parkville.

The disease has apparently been common in Australia for some years, but has been investigated but little. In 1912, Tidswell, in New South Wales, claimed it to be due to a definite germ known as *Bacillus necrophorus,* at any rate, in advanced cases.

In the work undertaken during the last few months every endeavour has been made to procure cases in the earliest stages. As a result, it appears that the disease first manifests itself as an affliction of the sheath. In one outbreak studied, about 74 per cent. of the wethers being used in a pasture rotation had become infected in some degree during a period of two to three weeks. The nature of the early lesions as studied microscopically, the rapid spread, and the fact that contagious pustular skin disease was present amongst another part of the flock, have suggested to the investigators the possibility of a so-called filtrable virus being the primary cause of the first sore, visible bacilli being secondary invaders.

To test this hypothesis, several sheep that have been received at the laboratory in an advanced stage of "rot" have been tested on the skin of the thigh for susceptibility towards contagious pustular skin disease. There has been either no reaction or a very poor reaction, whereas control animals, that is animals not suffering from rot, have given typical reactions. This is regarded as most suggestive, and further work will be carried out along these lines in order to see whether a suitable vaccine can be developed.

Infertility Problems.—One or two rams have been studied at the Veterinary Institute, Parkville, and one case examined has been shown to be due to injuries that the animal had received. Another case has persistently failed to yield to treatment, but has been sent to the Sydney Veterinary School for further study.

Internal Parasites (worms) in Sheep.—The Advisory Committee at its first meeting approved of work on this problem being carried out at three localities in Australia and under three different sets of climatic conditions. Small field stations have accordingly been established at "Meteor Downs," Queensland, "Gundowringa," New South Wales, and "Frodsley," Tasmania, the respective owners kindly providing the necessary areas and other facilities free of charge.

The trial at "Meteor Downs" is for the determination of the most effective method of controlling stomach worms. That at "Gundowringa" seeks to determine the effect of pasture improvement and heavier stocking on worm infestation, and the effects of rotation of pastures and medicinal treatment in controlling the trouble. The experiments at "Frodsley" are designed to show the relative efficiency of several standard methods of treatment against the small gastro-intestinal parasites.

All the above experiments are now fully under way, all the fencing, water supply, &c., necessary for the subdivisional paddocks having been erected and the experimental sheep selected, &c. All these sheep have been individually weighed twice, that is prior to the commencement of the experiment and at the end of the first month. It is, of course, too early to draw any conclusions whatsoever as to the results of these experiments, which are not expected to give any definite evidence one way or the other for at least a period of six months.

In addition to the above field work some investigations are being undertaken at the University of Sydney on—

(1) The life cycle and methods of control of the lung worm of sheep.

(2) The pathogenic importance of the small tricho-strongles of sheep.

(3) The effects of medicinal agents given in licks in the control of stomach worm infestation.

(4) The elaboration of a method of treatment for the nodule worm of sheep.

Recent Work—Pregnancy (or Twin Lamb) Disease in Ewes, and the so-called "Pulpy Kidney" Disease in Young Lambs.—In addition to the foregoing animal health programme, arrangements have recently been made for the carrying out of some investigations on both the above mentioned diseases. The work is centred in Tasmania, but the results, of course, will be applicable throughout those districts in Australia where fat lamb production is undertaken. The two maladies are serious in their incidence, particularly to the sheep-owner who concentrates on fat lamb and sheep production, although they occur from time to time among other sheep maintained entirely for wool production. Comparatively little is known as to the cause of the troubles, but what evidence there is indicates that they are at least associated with nutrition, and have no bacterial causation. Many factors, however, are still obscure.

The Role of Pasture Species in Regions of Winter Rainfall and Summer Drought.

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The following article by two officers of the Waite Agricultural Research Institute has been kindly furnished by Professor A. E. V. Richardson, Director of the Institute. It contains much information that is fundamental to the improvement of present practices of Australian pasture management in the so-called "Mediterranean" zone of winter rainfall and summer drought. Arguments are put forward in support of the use of perennials rather than annuals in many parts of this zone. In view of the importance to Australia of her annual grass crop—marketed as wool, meat, butter, &c.—the article will be found to be of wide interest.—Ed.

1. Introduction.

The main grassland regions of Australia have previously been outlined in brief by Richardson,* whose classification is approximately as follows:—

(1) *The tropical northern area,* dominated by summer or monsoonal rains, and located in eastern Queensland, north-eastern New South Wales, the Northern Territory, and the north-west of Western Australia.

(2) *The humid south-eastern area* of more or less regular rainfall, including the highlands and the territory east and south of the Great Dividing Range in New South Wales and Victoria, and Tasmania.

(3) *The southern grassland region of winter rainfall* (*vide* Plate 1), which coincides approximately with the cereal belt in New South Wales, Victoria, South Australia, and Western Australia, and portions of the pastoral areas bordering this belt. The mean annual rainfall is between 15 and 40 inches, of which the greater portion falls during the autumn-spring period. The summers are characterized by aridity, and the climate is essentially of the Mediterranean type.

(4) *The arid interior,* with a mean annual rainfall of less than 15 inches, forming more than one-third of the continent. This area is located in south-western Queensland, western New South Wales, and over the greater portion of South Australia and Western Australia. The rainfall here is erratic in character, and a relatively small proportion of the sheep and cattle of Australia are maintained in this zone, principally on large stations, under extensive grazing conditions.

* This *Journal* **2**: 5, 1929.

The pastures of the tropical northern area are composed largely of indigenous summer grasses, e.g., Mitchell grasses (*Astrebla* spp.), panic grasses (*Panicum* spp.), blue grasses (*Andropogon* spp.), and love grasses (*Eragrostis* spp.). These are not dealt with in this paper.

The arid interior contains much desert with porcupine grass (*Triodia* spp.), and perennial pastures of saltbush (*Atriplex* spp.) and bluebush (*Kochia* spp). Certain indigenous fodder trees are also of value, and ephemeral vegetation is abundant following sporadic rains.

The zone of importance for pasture development in Southern Australia (as distinct from the State of South Australia) includes the humid area of fairly regular precipitation and the region of effective winter rainfall. These may be termed the "humid" area and the "Mediterranean" area respectively. A large proportion of the sheep population is maintained in country with 15 to 25 inches of rain in the "Mediterranean" area. The line of maximum concentration coincides approximately with the 18 to 20-in. line of rainfall south from the Tropic of Capricorn.

The "humid" area is definitely perennial pasture country. A number of suitable species and improved strains of proved value for permanent pasture in this zone are available, e.g., *Paspalum dilatatum, Phalaris tuberosa,* Kikuyu grass (*Pennisetum clandestinum*), and permanent strains of perennial rye grass, cocksfoot, white clover, and strawberry clover. Considerable improvements are possible with the application of knowledge already in hand, viz., by the utilization of the most suitable of these species and their strains for particular conditions, and top-dressing with phosphatic and nitrogenous fertilizers where necessary, combined with sound pasture management.

In the "Mediterranean" area, however, the species problem is still unsolved, and this area is of particular importance from the viewpoint of species and strain investigation in relation to climatic factors. Data concerning the role of pasture species in the "Mediterranean" type of climate have not previously been published, but Nelson* has recently presented a thesis in favour of the self-regenerating annual. The present paper aims at a review of the pasture species problem in the area of winter rainfall and summer drought, based chiefly on observations made within this zone over a period of six years, and data obtained at the Waite Institute, Adelaide, during the last three years.

2. The Climatic Conditions of the "Mediterranean" Zone.

The climatic conditions at Adelaide, in comparison with those of typical "Mediterranean" centres, are indicated in Table I., the data of which† were supplied by the British Meteorological Office, South Kensington, London, in 1928, and justify the use of the term "Mediterranean" in respect to the Adelaide environment.

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* *Ann. App. Biol.* **17**: 796, 1930.

† Trumble, H. C.: Report to the Empire Marketing Board on Pastoral Conditions in Palestine and French North Africa, 1928. (Unpublished.)

TABLE I.—Showing a Summary of the Meteorological Conditions at Adelaide (South Australia), Cadiz (Spain), Gallipoli (Turkey), Jerusalem (Palestine), Fez (Morocco).

Latitude.	Adelaide, 36° S.	Cadiz, 36° N.	Gallipoli, 42° N.	Jerusalem, 32° N.	Fez, 34° N.
Mean seasonal temperature °F.— May 1–Oct. 31, S. Hemisphere .. Nov. 1–Apl. 30, N. Hemisphere ..	56	57	54	51	55
Mean dry period temperature °F.— Nov. 1–Apl. 30, S. Hemisphere .. May 1–Oct. 31, N. Hemisphere ..	70	71	72	70	73
Mean annual rainfall (ins.) ..	21	24	20	23	21
Mean seasonal rainfall (ins.) ..	15	19	13	22	17
Percentage of total rainfall falling during seasonal six months ..	72	79	65	96	81
Number of years' records	80	13	30	23	12

The mean annual rainfall at the Waite Institute over six years is 22.68 inches, of which 74.5% was received during the 1 May-31 October period. The mean annual evaporation is 61.60 inches, of which 70.5% was lost during the 1 Nov.-30 April period.

Fig. 1, Plate 1, shows the approximate boundaries of the zone in Australia receiving effective winter rainfall and periodic summer drought. The boundaries employed are the 15-in. isohyet and the coast in Western Australia and South Australia, the 15-in. and 30-in. isohyets in Victoria, and the 15-in. isohyet and Griffith Taylor's boundaries of winter rainfall and evenly distributed rainfall* in New South Wales. The zone thus arbitrarily differentiated is shown as a shaded area, and coincides fairly closely with the climatic zone under review.

The period of "physiological stress" is particularly marked in Western Australia and in South Australia. In the eastern portion of the Continent, the rainfall tends to be more evenly distributed throughout the year, and the summer temperature lower, with resultant extension of the growing season and shortening of the drought period.

3. Agricultural Areas of Winter Rainfall and Summer Drought.

The agricultural areas of the "Mediterranean" zone include three main classes of country, viz.:—

(1) The irrigation areas watered from the Murray River and its tributaries, including the Murrumbidgee irrigation area and the Goulburn and Murray schemes in northern Victoria.

(2) The area of relatively liberal or extended precipitation, receiving more than 20 to 25 inches per annum.

(3) The winter cereal cultivation belt receiving 15 to 25 inches per annum.

(*a*) *Irrigation Areas.*—The majority of the irrigation areas are capable of maintaining high production perennial pastures provided that suitable species and strains are employed, and the necessity for high soil fertility and sound pasture management recognized. The establishment of pastures composed of selected long-lived strains of

* Advisory Council for Science and Industry, Australia. Memoir No. 1 (1918).

perennial rye grass, such as New Zealand certified permanent pasture rye grass, Akaroa cocksfoot, *Phalaris tuberosa,* New Zealand wild white and strawberry clovers, is probably the most effective means of utilizing the swamps of the lower Murray River. High yields of nutritious fodder have been obtained from this type of pasture at Wood's Point, near Murray Bridge, South Australia, and the level of production is high throughout the year. Rotational grazing combined with the application of phosphatic and nitrogenous fertilizers will increase the production and longevity of this type of pasture, and the use of lucerne and maize for hay and ensilage is a further means of increasing the output from these areas.

(*b*) *Areas of Liberal Rainfall.*—The second class of country receives the milder type of Mediterranean climate, and subterrranean clover has been found suitable ecologically over most of this area. The main improvements effected during the past decade have been the result of the exploitation of this species and/or the top-dressing of pastures with superphosphate.

(*c*) *The Cereal Belt.*—On the cultivated soils of the winter cereal belt, temporary pasture only is required, forming part of the farm rotation employed. For this purpose, varieties of oats, early varieties of peas, and Wimmera rye grass are available. There is a class of country in this belt, however, which is unsuitable for regular cultivation owing to steepness of grade, to a stony or gravelly nature, or to wetness in winter. This must always be regarded as grazing country, but much of it is suitable for one or two seasons of cultivation for the purpose of laying down permanent pasture. Wallaby grass (*Danthonia penicillata*) and trailing saltbush (*Atriplex semibaccatum*), two indigenous perennials of value, are found growing naturally on this class of country in South Australia.

4. Pastures of the Areas of Winter Rainfall and Summer Drought.

The natural pastures of the zone under review are for the most part transitional grassland derived by clearing from climax associations of sclerophyll forest, savannah, mallee, and sclerophyll woodland.* The principal indigenous grassland species in the South Australian portion of the zone are kangaroo grass (*Themeda triandra*), *Microlaena stipoides, Agropyrum scabrum,* wallaby grasses (*Danthonia* spp.), and spear grasses (*Stipa* spp.). Three environmental factors of importance have characterized the conditions under which these grasses have developed:—

1. A soil series deficient in readily available phosphate.
2. A climate characterized by periodic summer drought.
3. The mild biotic influence of the light grazing marsupial.

The introduction of close grazing animals has considerably altered the biotic factor, with resulting elimination of indigenous grasses previously abundant. Further, the unconscious introduction of plants from Mediterranean countries has supplied increased spring competition. Most of the acclimatized exotics are free-seeding annuals, or perennials provided with an underground means of withstanding the summer. Typical examples of the annual species are barley grass (*Hordeum murinum*), silver grass (*Festuca myuros*), burr trefoil (*Medicago denticulata*), and geranium (*Erodium botrys*). Common

* J. A. Prescott. Vegetation Map of Australia. Council for Scientific and Industrial Research, Australia. (1931.)

perennials are cat's ear (*Hypochaeris radicata*), soursob (*Oxalis cernua*), and onion grass (*Romulea parviflora*). These species are able to withstand hard grazing owing partially to inaccessibility, e.g., *Erodium, Hypochaeris;* to low palatability, e.g., false brome (*Brachypodium distachyum*), *Oxalis,* haresfoot clover (*Trifolium arvense*); and to the rapid and efficient production of seed in the annual species, or to the underground reserves of perennials such as *Romulea, Oxalis,* and *Poa bulbosa.* Many of the annuals adopt a semi-prostrate habit of growth under grazing, become unpalatable at flowering, and produce inedible or injurious seed in considerable quantities at maturity. The perennials are mostly low yielding or unpalatable in nature. In general, the species forming the natural pastures of this zone are low in their demands on the fertility of the soil.

Investigations carried out at the Waite Institute have shown that the replacement of indigenous perennial species by exotic annuals is accelerated by top-dressing with soluble phosphate. The principal constituent of the unmanured plot in a series of tests commenced in 1925 has been *Danthonia.* Where an annual top-dressing of 185 lb. superphosphate was applied however, *Danthonia* was considerably reduced at the outset and is still dominated by annual species. It has been shown in pot cultures* that *Danthonia* definitely responds to the application of soluble phosphate. Its reduction on top-dressed land is therefore probably due to the differential response of individual species in combination with the competition factor. Over five years, the mean response of the natural herbage to top-dressing has been 57.0% of the dry weight of herbage produced. This response is made up chiefly of increased winter and spring growth. The growing season is actually shorter than on unmanured land, and the mature pasture is in a condition of low nutritive value during the long November to May period.

The results of investigations concerning the productivity of a top-dressed "natural" pasture, carried out by Davies and Sim,† indicate that the active development of this type of pasture is confined to a relatively short period.

With the exception of a little growth from unpalatable summer weeds, the production from the pasture took place between June and November. Under a system of monthly cuts, 41.6 per cent. of the total yield was produced between 8th September and 8th October, and 68.1 per cent. between 8th September and the middle of November. During October and November, the nutritive value of the herbage was considerably reduced by the formation of seed, much of it valueless.

The work of Richardson, Trumble, and Shapter* has shown that approximately 60 per cent. of the total nitrogen absorbed by the plant, and 78 per cent. of the phosphoric acid, may be present in the mature seed of typical winter annuals. Where the seed is inedible, as it is in the case of many exotic annual species, this loss greatly accentuates the low feeding value of the material available to stock during summer.

The proportion of seed produced by natural and cultivated pasture species under investigation at the Waite Institute has been found to vary from 21.1 per cent. to 58.1 per cent. of the total dry weight, with a mean value of 35.7 per cent. in the case of twelve self-regenerating

* Council for Scientific and Industrial Research, Australia. Bulletin 49, 1931.

† Council for Scientific and Industrial Research, Australia. Pamphlet 18, 1931.

annual species. In the case of six successfully cultivated perennial species, the range was from 2.6 per cent. to 24.9 per cent., with a mean value of 13.4 per cent.

In the majority of the annual naturally growing species, the seed is mechanically unsuited to the nutrition of live stock. Sheep are able to masticate and assimilate the seed of burr trefoil, subterranean clover, and Wimmera rye grass, and whatever seeds of these and other species were picked up by sheep during summer would act as a mineral and protein concentrate.

5. The Improvement of Pastures.

The improvement of pastures in the Mediterranean type of climate depends on the three factors—(*a*) soil fertility, (*b*) the utilization of most suitable species and strains, and (*c*) management. An important outcome of the investigations at the Waite Institute has been the conclusion that the value of natural pastures is limited chiefly by the nature of the herbage species present. In the search for improved plant types, 320 individual species and 337 additional samples of five of these species have been tested. The principal characteristics sought have been—(*a*) drought resistance, (*b*) high productivity, (*c*) capacity to produce during the "bottle neck" or period of normal shortage, and (*d*) potentially high nutritive value.

The types investigated have provided abundant material for a consideration of the relative suitabilities of annual and of perennial pasture species for the Mediterranean type of climate. To be of value for permanent pasture, the annual must be self-regenerating, as in the case of subterranean clover. That is to say, portion at least of the seed produced must be conserved either as a result of self burial or mechanical resistance during ripening and at maturity, or as a result of "nursing" towards maturity, which involves considerable loss in nutritive value.

(*a*) *Advantages of Annuals.*—At first sight, the self-regenerating annual would apear to be eminently suitable for areas of summer stress because of its efficient means of escaping drought and of providing a pasture during the ensuing wet season. In general, its establishment from seed is vigorous and its yield is high during the first year. This is particularly true of Wimmera rye grass on soils of high nitrogen content. The rapidly growing annual is also better adapted to compete with weeds during the seeding year and to spread by natural means. Its profuse production of seed at the conclusion of the growing season renders it immune from environmental influences during the critical summer period, and the price of the seed is low.

The type is thus well adapted to the alternating severity of the climate. On the other hand, a number of serious objections are inherent in the annual as a basis for permanent pasture.

(*b*) *Disadvantages of Annuals.*—A pasture composed of annual species is notoriously unstable, and this leads to difficulties in its control. Its tendency towards a restricted period of growth, involving negligible autumn and poor winter production followed by excessive development in spring, with ultimately a heavy loss of nutrients in the seed has already been stressed, and results in a serious "bottle neck" period of

shortage from February to May or from December to June, according to the locality and season. This frequently necessitates migration of stock or expensive hand feeding.

Probably the most serious drawback of the annual species is the lack of control. The botanical composition is almost entirely at the mercy of the annual seasonal conditions. Methods of improvement must necessarily incorporate a large measure of control over the constituent species, otherwise improvement cannot be maintained for successive seasons. Top-dressing, harrowing, and grazing by stock are too weak an influence on annual species to counteract the variations in climatic forces met with.

The outstanding example of the desirable permanent annual is subterranean clover, with its prostrate habit and low availability of feed during winter, but provision of self-sown and available seed. On the other hand, annuals which provide feed rapidly in autumn are generally erect in habit, and, therefore, incapable of withstanding severe grazing, e.g., *Vicia* spp., *Bromus* spp. The seasonal growth of subterranean clover and Wimmera rye grass, which are the two most desirable of the many annual species available, suffers by comparison with that of *Phalaris tuberosa,* Hawkes Bay rye grass, lucerne, and trailing saltbush.

(*c*) *Annuals versus Perennials.*—The importance of competition from annuals and perennials already established in pastures must not be overlooked. The annual pasture flora of southern Australia has developed over a large number of years a high degree of suitability to the environment and grazing practice which characterizes the "Mediterranean" zone in Australia, and it is possible that many years may elapse after the introduction of a new species before suitable ecotypes are evolved. We have no evidence that the present forms of subterranean clover, Wimmera rye grass, *Phalaris tuberosa,* and *Paspalum dilatatum* are identical with the original introductions, or that the original introductions were immediately successful in the sense that these species are successful to-day. For this reason, the immediate possibilities of exotic species introduced to Australia for the first time are viewed with substantial reserve.

The Waite Institute has introduced from Palestine, Southern France, Italy, Northern Africa, and other Mediterranean sources, and from Arizona, approximately 200 annual species, none of which has so far demonstrated any immediate value approaching that of a dozen or more perennials and annuals already established in Australia. The potentialities of this latter (Australian) material are sufficiently great to warrant considerable investigation with these species alone.

There are a number of perennial species which are capable of withstanding the summer drought in a dormant vegetative condition. *Danthonia, Phalaris tuberosa,* perennial veldt grass (*Ehrharta calycina*), and certain strains of perennial rye grass are cases in point. Moreover, two summer growing perennials, viz., lucerne and trailing saltbush (*Atriplex semibaccatum*) are capable of producing feed during the period of shortage, and they also persist at Adelaide. These perennials have the advantage of stability due to perennial root occupation, which prevents opening up of the pasture, erosion by wind and water, and the entrance of undesirable weeds. They are, therefore, more amenable to control, and are capable of providing herbage over an extended period of the year. The particular advantage of these

species at the Waite Institute lies in their markedly increased production during the autumn months, and consequent reduction of the "bottle neck." The true long-lived perennial herbage plant as shown by Stapledon,* Levy, and Davies,† and confirmed by frequent observation at the Waite Institute, is characterized by moderate seed production, low stemminess, high leaf production, increased nutritive value, and persistency.

The growth season of perennials, particularly as mixed pasture, is markedly extended, because within a few days of the first rains feed is vigorously produced from vegetative reserves, whereas annuals may take several weeks to germinate, and six or more weeks to provide feed in quantity. Further, there is a distinct response to summer rainfall where this occurs, e.g., *Danthonia,* perennial rye grass, lucerne, trailing saltbush, and rib grass (*Plantago lanceolata*). The winter annual does not, and cannot, respond to summer rainfall.

The perennials noted, with the possible exception of *Danthonia,* are higher fertility demanders than the annual species, and therefore respond markedly and surely to cultivation and the application of fertilizers. Their yield is higher, and more evenly maintained throughout the season. Generally speaking, they are leafier and do not transfer the major portion of their essential nutrients to the seed. In addition to their higher yield at the commencement and end of the rainy season, these species yield more nutritive material in spring than do the annuals. Further, their palatability is greater.

It must be admitted that perennial species have certain disadvantages, but these are not serious, and are more than outweighed by their obvious advantages. Their slower establishment from seed and lower yield during the first year are not serious in the "Mediterranean" winter of relatively mild temperatures. The greater expense of the seed as evidenced at present in *Phalaris tuberosa* is to a large extent due to factors of supply and demand. The case of *Phalaris tuberosa* is at present under investigation, and it is already evident that there is no fundamental reason why the price of this seed should not fall considerably, as was the case with subterranean clover. Two disadvantages of the perennial claimed by Nelson (*loc. cit.*) are the loss of nutrients in underground vegetative storage organs, and the relative lack of a capacity to spread naturally. The underground loss in *Phalaris tuberosa,* which has particularly obvious underground reserves, is only 25 per cent. compared with seed losses of 30 to 50 per cent. in many annuals, and moreover, practically all of the nutrients in this reserve become available to stock during the following autumn, whereas the nutrients of many seeds are lost, due to non-viability and seedling mortality.

The advantages of the gradual increase in carrying capacity by the slow stages of spread of a self-regenerating annual seem entirely illusory. The ploughing and re-seeding of any holding can and must always be done gradually, and can be arranged to suit the natural increase or any other increase in stock numbers. The initial capital expenditure per acre is higher for sowing down, but the increase in yielding capacity is so much more pronounced that it would seem a very profitable investment.

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* *J. Ecology* **16**: 1, 71–104. 1928.

† *N.Z. Jour. Agric.* **40**: 6, 363–385. 1930.

The possibility exists of providing for the summer "bottle neck" in two ways:—

(1) The yielding capacity of a good perennial pasture may be high enough to permit hay harvesting. With annual species in permanent pasture, the yield will be lower, and either the nutritive value poor or the permanency endangered, according to the stage of growth chosen.

(2) Lucerne or saltbush pastures may be used as summer paddocks.

From the above considerations, it is evident that, provided they can be found, high yielding perennial species capable of persisting under conditions of summer drought will be definitely superior as pasture types to the self-regenerating annual.

6. The Characteristics of Certain Species.

Investigations with different species, strains, and mixtures of herbage plants are being carried out by the Waite Institute at different South Australian centres, all characterized by the Mediterranean type of climate, but with intensities varying from severe summer drought at Gepp's Cross (18 inches rainfall), Saddleworth (20 inches), Waite Institute (23 inches), to shorter and milder periods of stress at Kybybolite (20 inches), Mount Pleasant (25 inches), Inman Valley and Mount Barker (32 inches), and Murray Bridge (summer irrigation).

At each centre, an acre of typical pasture land was ploughed, cultivated to a fine tilth, and divided into 80 randomized plots of 1-100th acre in area, 20 x 50 links, on which twenty pasture species, strains, and mixtures were sown in quadruplicate. In each locality, perennial species have been found capable of surviving the period of summer drought in either a vegetatively dormant or vegetatively active condition.

Wimmera rye grass (*Lolium subulatum*) was the most vigorous species in the first year, and was outstanding in the effectiveness of its initial establishment from seed. The chief problem involved in the use of this species is one of permanence in the absence of cultivation, and this appears to be dependent on management and on the maintenance of soil fertility, particularly of the nitrogen level in the second and subsequent years of the pasture.

The disadvantages of the winter annual, however, are inherent in this type, which is again low in autumn production, restricted in its period of active growth, low in nutritive value at maturity, and difficult to control. Prolonged dry weather following an early germination is liable to eradicate Wimmera rye grass, which does not possess the safeguard of hard seed and delayed germination, whereas perennials such as *Phalaris tuberosa* and Hawkes Bay rye grass live through the dry period apparently unaffected.

As a pioneer with subterranean clover, and on cultivated soils, in the lower rainfall areas of the wheat belt, Wimmera rye grass is the best and most readily established pasture species available, and considerable improvements are possible by means of its use under these conditions. Where the rainfall is more than 20 inches, however, and particularly where it is well distributed over the year and the soil of fairly good fertility, perennial species such as *Phalaris tuberosa* and Hawkes Bay rye grass are of much greater value for permanent pasture.

Annual canary grass (*Phalaris minor*) is similar in type and productivity to Wimmera rye grass under the conditions at Adelaide. With Wimmera rye grass available, however, this species is unnecessary, and in view of its presence in *Phalaris tuberosa* samples* and the confusion thereby caused, there is little justification for regarding it as a desirable species for the grassland areas in Australia generally.

Subterranean clover (*Trifolium subterraneum*) will always be valuable for country with over 20 inches per annum and with a favorable spring period, particularly as a pioneer on poor soils and as a producer of dry summer feed of high nutritive value. Much of the subterranean clover country, however, is suitable for permanent pasture composed of perennial grasses, such as Hawkes Bay rye grass, cocksfoot, and *Phalaris tuberosa,* and in areas with temperate summers or under summer irrigation, white clover is considerably superior to subterranean clover.

In the areas subject to a long period of summer drought, typified in South Australia by the Adelaide plains region, subterranean clover is a failure, owing to its susceptibility to the rapid onset of hot weather at the flowering stage. Strains that are four to six weeks earlier than the ordinary variety are at present under investigation for this more severe type of environment.

Prairie grass (*Bromus unioloides*), although capable of re-seeding at most of the centres where it was sown, is not regarded favorably owing to poor persistence under grazing, and it is unnecessary, with Wimmera rye grass and superior perennial species available.

Commercial (Southlands) perennial rye grass and Italian rye grass were found entirely unsuited to all centres. The reasons for their failure are their low persistence under grazing and under drought, poor regeneration from seed, and liability to take possession in the first year, leaving the pasture bare and open to weed entry in the second season.

Certified Hawkes Bay perennial rye grass (*Lolium perenne*) was the most vigorous perennial species from seed in the first year, and has successfully oversummered as a sward at all centres save Gepp's Cross and Saddleworth. Plots of this variety and of Wimmera rye grass were characterized by denseness of cover at an early stage and a high degree of resistance to the intrusion of weeds. Hawkes Bay rye grass has been the most successful grass under irrigation at Murray Bridge, and with *Phalaris tuberosa* has been outstanding at all other centres except Saddleworth and Gepp's Cross. On deep and fertile soils, its drought-resistance is considerably higher than has previously been assumed.

Western District (Victoria) rye grass from certain sources appears to equal Hawkes Bay rye grass in value for areas of periodic drought, but owing to the absence of certification and to the unreliability of Western District samples, certified New Zealand permanent pasture seed is more satisfactory.

Phalaris tuberosa has been the most successful permanent species in trials at the Waite Institute extending over six years, and has persisted as a perennial at all country centres. The value of this species lies in its active production of autumn and winter feed, high drought resistance, and permanence under grazing conditions. The germination

* *Jour. South Aust. Dept. Agr.* **34**: 38–44, 1930.

and early growth from seed are vigorous, but not so active as in Hawkes Bay rye grass. In addition, *Phalaris tuberosa* is more susceptible to competition and the entry of weeds than the rye grasses generally. Consequently, to establish *Pharlaris tuberosa* satisfactorily, active competitors in the first year, such as Italian rye grass, Wimmera rye grass, prairie grass, and *Phalaris minor* must be excluded from the mixture employed, and the seed sown on soil free from weeds. It is also important that the seed should be clean and of high quality. Satisfactory pastures of *Phalaris tuberosa* have been established with as low a seeding as 2 lb. per acre, where these factors were taken into consideration. Selection is being employed at the Waite Institute as a means of isolating superior strains of this species.

Perennial veldt grass (*Ehrharta calycina*) has persisted at the Waite Institute under conditions of summer drought, and ranks with Hawkes Bay rye grass and *Phalaris tuberosa* as a grass of high productivity and an extended period of growth. This species is still in the preliminary trial stage, but is promising for areas with more than 20 inches of rain, and particularly on light soils.

Cocksfoot (*Dactylis glomerata*) has been successfully established in the areas with a relatively mild summer period, and under irrigation. The development from seed during the first year is slow, but good swards have been obtained during the second year at Kybybolite, Mount Pleasant, Mount Barker, and at Murray Bridge. At the Waite Institute, a variety collected near Azrou (Morocco), where the rainfall is 23 inches per annum, has shown promise for country receiving 20 to 25 inches per annum. This type is slow to establish, but perennial plants in their third growing season have demonstrated a high degree of productivity and an adaptability to conditions of close grazing and severe summer drought.

Yorkshire fog (*Holcus lanatus*) and Waipu brown top (*Agrostis tenuis*) have persisted on poor soils in the wetter areas, where Waipu brown top in particular is of value as a sward former in mixtures. In general, these grasses are of little value however, as Hawkes Bay rye grass is a superior type where the fertility is good or can be improved, and on the poorer soils subterranean clover can be used as a soil improver.

Wallaby grass (*Danthonia*) has a possible place in areas too dry for *Phalaris tuberosa,* Wimmera rye grass, or subterranean clover. Superior strains of *Danthonia* have been selected at the Waite Institute, but the cost of establishment of any species on areas of low potential capital value must be taken into consideration. The type is an example of a free-seeding perennial capable of extensive spread by natural means in country where the competition factor is absent owing to low soil fertility or erosion. The spring production of *Danthonia* is low, but feed is produced fairly continuously over the greater portion of the year.

Lucerne (*Medicago sativa*) is the most successful leguminous herbage plant at the Waite Institute, and will persist in areas too arid for subterranean clover. Its drought resistance is dependent on a vigorous deeply penetrating root system in contact with subsoil or other underground reserves of moisture. This species possesses a high nutritive value, soil improving qualities, and a capacity to produce feed

during the summer and early autumn period of shortage. At Adelaide, its successful establishment is greatly dependent on the time of the year at which the seed is sown.

Trailing saltbush (*Atriplex semibaccatum*) is an indigenous perennial species found growing naturally in South Australia at Minnipa (14 inches), Murray Bridge (14 inches), Saddleworth (20 inches), and on the Adelaide plains (17-21 inches), in uncleared country or where not eliminated by competition and/or overgrazing. At the Waite Institute, it has been successfully cultivated under field condition, yielding as much as 4.76 tons of dry herbage (containing 2.45 tons of dry leaf) during the 1929-30 summer and autumn period. The protein and mineral contents of this species are particularly high*, and the root system extends to a considerable depth into the subsoil, as in the case of lucerne. The water requirement of *Atriplex semibaccatum* is approximately one-half that of lucerne, which indicates a higher potential production on limited quantities of subsoil moisture during the summer period. *Atriplex semibaccatum* has also been shown to withstand continual cutting with shears, and appears to be better adapted to conditions of close grazing than the more xerophytic species of *Atriplex.*

Additional species which have been successful in Western Australia and in other portions of the area of winter rainfall and summer drought in Australia, but which have so far proved failures at the Waite Institute, are the Tangier pea, blue lupin, drooping-flowered clover, clustered clover, and King Island melilot. These have a definite value in limited areas under special types of conditions, but as yet there appears to be no justification for their widespread use over the main portion of the zone under review.

The investigations described above indicate that for the classes of country typified by the eight centres employed in South Australia, five main pasture types, viz., Hawkes Bay rye grass, *Phalaris tuberosa,* Wimmera rye grass, lucerne, and subterranean clover, with a number of additional types as yet tentatively suggested pending further investigation, viz., perennial veldt grass, *Atriplex semibaccatum,* selected strains of cocksfoot and of *Danthonia,* provide a basis of pasture types suitable for country receiving 18 to 32 inches rainfall per annum with a winter incidence followed by summer drought. With these as the main source of plant material, the problem becomes an ecological one, involving their relation to climatic factors, soil fertility, and management, and directed towards the most economically effective means of utilizing these pasture types.

* Council for Scientific and Industrial Research, Australia, Bulletin 49 (1931).

The Control of Soft Rot (Water Blister) of Pineapples caused by *Thielaviopsis paradoxa.*

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Summary.—Soft-rot of pineapples, known in the southern markets as water blister, causes an annual loss estimated at £10,000.

According to counts made in the Sydney markets, infection through the cut stems causes 75 per cent. of the total loss, and infection through the fruit 25 per cent.

Infection through the stem may be almost altogether prevented by the appliction of borax, boric acid, or calcium hypochlorite to the cut surface of the stem within not more than five hours of cutting the fruit. Salicylic and benzoic acids are much more efficient in this respect.

Salicyclic and benzoic acids go into solution in the stem, and minute amounts enter the core of the fruit, but none has been found in the edible portion.

Benzoic acid may be used on fruit intended for sale in the markets of New South Wales, but the use of borax, boric acid, or salicylic acid is not viewed with favour by the Health Department. For commercial application, an alcoholic solution of benzoic acid of not less than 10 per cent. strength, or a mixture of one part acid with not more than four parts of kaolin is recommended.

Transportation and storage of fruit at low temperatures is also suggested as a means of control.

1. Introduction.

According to reports from dealers, soft rot of pineapple caused by *Thielaviopsis paradoxa,* known in the southern markets in New South Wales and Victoria as "water blister," has caused appreciable loss during the past 20 years. During the summer months, pineapples shipped from Queensland, apparently in excellent condition, may arrive at the Sydney or Melbourne market more or less rotted (Plate 2, Figs. 1, 2, 3), the juice of the fruit oozing out of them and dripping copiously from the crates. In the course of inspection of fruit in the Sydney markets, we have observed crates in which more than one-half the fruit was unfit for sale. As far as we are able to judge from reports from various sources, the amount of loss has been steadily increasing, and for some few years has been, perhaps, the limiting factor in the industry. Only those growers who have been able to dispose of their fruit free, or nearly free, from disease in the southern markets have been able to obtain adequate returns for their labour and capital.

In May, 1928, the Queensland Committee of Direction of Fruit Marketing approached the Queensland Government on the subject, and

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the State Department of Agriculture and Stock then asked the Council for Scientific and Industrial Research to make Dr. Dickson's services available for advising regarding the lines on which an investigation might be conducted. During June, 1928, visits were accordingly made by Dickson and Simmonds to plantations whose owners had reported heavy losses, but no definite information regarding the nature of the disease could then be gathered. On returning to Sydney, Dickson visited the markets, but samples of diseased fruit, described by the dealers as typical water blister, were not available until February, 1929, when he recognized the disease as soft rot. Specimens were taken to the temporary divisional laboratories at the University of Sydney, where the organism was isolated in pure culture. About the same time, speciments of the same disease were seen by Angell and Simmonds in fruit in the Queensland canning factories. Shortly afterwards, a co-operative investigation was decided upon, the Council for Scientific and Industrial Research agreeing to handle the marketing end of the problem while the Queensland Department of Agriculture and Stock undertook responsibility for the plantation aspect of the joint project. The Committee of Direction of Fruit Marketing very kindly agreed to provide the pineapples necessary for the experimental shipments and also to bear the cost of transportation. This co-operation has been much appreciated.

The responsibility for work in Queensland devolved upon Simmonds, assisted when necessary by Mr. Mandelson, while Angell supervised the work at the receiving end, viz., the laboratories of the Division of Plant Industry, and the Sydney markets. Mr. W. V. Ludbrook and Mr. E. H. Kipps assisted in market examinations of commercial consignments and the former in laboratory studies of the causal organism and of inoculation and other tests during 1929.

After many experiments with various concentrations of formalin (which were applied to the fruit in different ways), Bordeaux paste, sulphur, and other compounds, all of which were found to be useless in controlling the disease, boric acid or borax rubbed on the cut stems of the fruit was found to be efficient; calcium hypochlorite more so; and benzoic and salicylic acids, respectively, applied in the same way, resulted in complete control of stem-end infection.

After most of the experimental work recorded in this paper had been completed, the Department of Health in New South Wales advised that only benzoic acid would be allowed for treating pineapples intended for sale in that State. The application of the chemical to the cut stems of the fruit within not more than five hours of picking should result in material reduction of loss by soft rot in commercial consignments. The problem of adequately controlling direct infection of the fruit itself, which is responsible for some 25 per cent. of the total loss, awaits further investigation.

In this paper, a few results of laboratory work are mentioned incidentally. Short paragraphs deal with the names and economic importance of the disease, whereas experimental methods and results are discussed in somewhat greater detail.

2. Names of the Disease.

Water blister of pineapple caused by *T. paradoxa* is referred to in publications from Hawaii, Florida, and Porto Rico as soft rot, fruit rot, and black rot of pineapple respectively. In the publications of

the Queensland Department of Agriculture and in the pineapple-growing districts of that State, it is known as "Thielaviopsis soft rot," whereas in the Sydney and other southern markets the term "water blister" is generally applied. As the latter term does not give even a vague idea of the symptoms, as the older and simpler names are more accurately descriptive, and as multiplicity of names tends to lead to confusion, it is recommended that the term "soft rot," an abbreviation of the name which is used in Queensland, should be applied also in the southern markets.

3. Economic Importance.

According to the *Official Year-Book* of the Commonwealth of Australia, the area under pineapples in 1928-29 was 4,830 acres. In the same year, the gross value of the crop was estimated at £228,653. During the previous year, the Queensland Committee of Direction of Fruit Marketing reported that the number of cases of pineapples sent to canning factories was 240,728, and to the Sydney and Melbourne markets 145,893, the total being 386,621.

The greater part of the crop is marketed during the months of February, March, and April, the growers preferring in many instances to send their fruit south on account of the greater financial return they receive in comparison with that from the local canneries. Fruit sent to the southern markets during those months, however, may develop soft rot in transit, resulting in general in greater loss to the growers than would have been the case had it been sent to the local factories. The loss resulting directly from the rotting of the fruit and indirectly by selling to the canneries, where lower prices are obtained, is estimated by the above-mentioned Queensland Committee at approximately £7,500 annually. Significant as this figure may be, it must be remembered further that the loss sustained by many of the growers is so great that their labour income is seriously reduced. In addition, the cost of transportation and the losses sustained by hundreds of retail greengrocers must be taken into account. The total loss may thus be nearly £10,000 per annum.

4. Experimental Methods and Results.

Through the courtesy of the Queensland Committee of Direction of Fruit Marketing, some 190 cases of pineapples have been supplied and transported, free of cost, to the Divisional laboratories during the three summers that our experiments have been in progress. On account of the seasonal character of the disease, shipments were made only during the months of February, March, April, and the early part of May. The fruit was picked, treated, and packed in Queensland by one of us, and examination was made in Sydney (during 1929) and in Canberra (1930 and 1931) by the others.

The first consignment of fruit in each of the years 1929 and 1930—five cases of fruit in the fourth consignment, despatched on 21st March, 1929; six cases of the sixth consignment on 4th April, 1929; and one case of the eighth consignment on 11th April, 1929—were designed to determine to what extent the fruit would become infected during the operations of picking, packing, and transportation. They were not artificially inoculated with the causal organism. Some of the

fruit in the above-mentioned cases was deliberately exposed to conditions which were thought to favour natural infection, some were taken from commercial packs, others were very carefully picked and packed, while others were protected from infection by the use of fungicides in addition.

In these consignments, infection was not general enough to enable us to draw any definite conclusions regarding the efficacy or otherwise of the various methods of treatment. Consequently, all the fruit treated with fungicides in 1929 and succeeding years were first artificially inoculated by spraying with suspensions of conidia of the causal organism.

During the 1929 season, formalin in different concentrations applied for varying lengths of time to the whole fruit, or in some cases only to the stem end, Bordeaux paste, sulphur, solutions of boric acid, and mixtures of formalin and Bordeaux were tried in various ways, but with negative results. None gave any control of the disease except those concentrations of formalin which were so strong as to turn the fruit brown and to render it unfit for sale.

The presence of abnormally large numbers of conidia on the surface of the fruit itself as a result of spraying should be duly considered when examining the figures in the Table below, bearing in mind the fact that the fungicides were applied to control infection only through the cut stem. It is obvious that it would be uneconomical to attempt the commercial application of benzoic acid to the entire fruit. Consequently we concentrated our efforts on the control of stem-end infection.

Details of the experiments with efficient fungicides are as follow:—

(*a*) *Salicylic Acid.*—The use of salicylic acid is at present allowed in New South Wales in the preservation of certain beverages, e.g., lemon and lime juice, and some canned or bottled articles of food, e.g., tomato-sauce. Bacterial and fungal growth is inhibited by it. The conidia of *T. paradoxa* fail to germinate in its aqueous solutions in concentrations not exceeding about 1 in 7,200.

Our seven experimental consignments during the summers of 1930 and 1931—totalling 277 pineapples in which salicylic acid crystals were applied to the cut stems after inoculation of the fruit with a conidial suspension of the causal organism—arrived and remained free from stem-end infection. Side infection, against which no preventive measures were taken, occurred in two shipments in the second week of March, 1930 and 1931, respectively The date of such consignment, the number of fruit used, their freedom from disease or otherwise are given in the accompanying Table. It should be noted in contrast that 236 out of 241 controls were diseased.

Tests in the Divisional laboratory showed that salicylic acid went into solution in the cell sap of the stem of the fruit. As there was the possibility that some of it might penetrate the fruit itself, samples for analysis were submitted to the Department of Health of New South Wales. A copy of the Department's report is given as Appendix 1.

According to the New South Wales *Food and Drugs Act* 1908, Revised Issue 1925, not more than 2 grains of salicylic acid are

allowed per pint of lemon or lime juice, 3 grains per gallon of beer, and 2 grains per pound of tomato-sauce. In further correspondence with the Department of Health, these figures were submitted, and a ruling asked for regarding the use of salicylic acid as a preventive of soft-rot. The answer was as shown in Appendix 2.

Although very satisfactory in controlling the disease, as well as being relatively cheap, we are unable to recommend the commercial application of salicylic acid on account of the above ruling.

TABLE 1.—RESULTS OF SOME EXPERIMENTAL CONSIGNMENTS.

Treatment. Rubbing cut stems with—	Dates of Shipment.	First Test. No. of Fruit.	Healthy.	Stem Infection.	Side Infection.	Second Test. No. of Fruit.	Healthy.	Stem Infection.	Side Infection.
Benzoic acid	8.4.30, 2.5.30, 18.2.31	40	37	..	3	80	80	..	..
Controls	27.2.31, 6.2.31	20	..	20	..	80	..	80	..
Calcium hypochlorite	27.2.31, 6.3.31	22	21	1	..	36	7	1	28
Controls	.. ..	24	..	24	..	18	..	18	..
Boric acid	5.4.29, 18.4.29	9	7	..	2	24	16	5	3
Controls	21.2.30, 21.2.31, 6.3.31	..	..	..	..	20	..	20	..
Borax acid	6.3.30, 18.2.31	20	17	3	..	21	21	..	..
Controls	6.3.31 ..	20	..	20	..	39	..	39	..
Salicylic acid	21.2.30, 6.3.30, 11.3.30	20	20	..	..	40	40	..	..
Controls	2.5.30, 18.2.31, 27.2.31	20	..	20	..	20	..	20	..

Treatment. Rubbing cut stems with—	Third Test. No. of Fruit.	Healthy.	Stem Infection.	Side Infection.	Fourth Test. No. of Fruit.	Healthy.	Stem Infection.	Side Infection.	Fifth Test. No. of Fruit.	Healthy.	Stem Infection.	Side Infection.
Benzoic acid	16	12	..	4	7	7	..	..	21	10	..	11
Controls	39	..	39	..	24	..	24	..	18	..	18	..
Calcium hypochlorite	..	..	..	..	..	..	..	..	..	..	..	..
Controls	..	..	..	..	..	..	..	..	..	..	..	..
Boric acid	20	19	1	..	19	16	..	3	18	2	2	14
Controls	20	..	20	..	39	..	39	..	18	..	18	..
Borax acid	18	1	..	17	..	..	..	..	..	..	..	..
Controls	18	..	18	..	..	..	..	..	..	..	..	..
Salicylic acid	120	73	..	47	40	40	..	..	20	17	..	3
Controls	40	5	35	..	80	..	80	..	39	..	39	..

TABLE 1.—RESULTS OF SOME EXPERIMENTAL CONSIGNMENTS.—*continued.*

Treatment.	Sixth Test.				Seventh Test.				Totals.			
Rubbing cut stems with—	No. of Fruit.	Healthy.	Stem Infection.	Side Infection.	No. of Fruit.	Healthy.	Stem Infection.	Side Infection.	No. of Fruit.	Healthy.	Stem Infection.	Side Infection.
Benzoic acid	..	..	..	..	..	..	..	..	164	146	..	18
Controls	..	..	..	..	..	..	..	..	181	..	181	..
Calcium hypochlorite ..	..	..	..	..	..	..	..	..	58	27	2	29
Controls	..	..	..	..	..	..	..	..	42	..	42	..
Boric acid	..	..	..	..	..	..	..	..	90	60	8	22
Controls	..	..	..	..	..	..	..	..	97	..	97	..
Borax acid	..	..	..	..	..	..	..	..	59	39	3	17
Controls	..	..	..	..	..	..	..	..	77	..	77	..
Salicylic acid	13	13	..	..	24	13	..	11	277	216	..	61
Controls	24	..	24	..	18	..	18	..	241	5	236	..

(*b*) *Benzoic Acid.*—Experimental consignments involving the use of benzoic acid rubbed on the cut stems of 164 pineapples were made on 4th April and 2nd May, 1930, 18th and 27th February and 6th March, 1931. One hundred and eighty-one fruit similarly inoculated with the conidia of *T. paradoxa* served as controls. Without exception the latter were diseased. Of the 164 pineapples the cut stems of which were rubbed with benzoic acid, eighteen became infected directly through the fruit, but none through the stem. Details regarding all the consignments are given in the accompanying Table.

With a view to reducing the cost of treatment with benzoic acid, three more experimental consignments were tried in which alcoholic solutions and mixtures of the crystals with kaolin were used. Complete control of stem-end infection was obtained by brushing on solutions of 10 per cent. strength or more, or by rubbing the cut stems in mixtures of one part of benzoic acid with not more than four parts by weight of kaolin. We therefore recommend either means for commercial use. Approval of the use of benzoic acid has been given by the New South Wales Department of Health, as may be seen on reference to Appendix 2.

(*c*) *Borax and Boric Acid.*—In tests of the efficacy of these substances, a total of 149 pineapples were inoculated by spraying with a conidial suspension of the causal organism followed by the application of borax and boric acid to the cut stems. Consignments were sent from Queensland on 5th and 18th April, 1929, 3rd March and 4th April, 1930, 18th and 27th February, and 3rd March, 1931. One hundred and seventy-four pineapples similarly inoculated were used as controls, but all arrived infected. Of the 149 rubbed with borax or boric acid, eleven developed stem and 39 side infection. Details are given in the accompanying Table. In comparison with salicyclic and benzoic acids, they are less efficient, but have the advantage of being relatively inexpensive. Consequently, it should be more economical

to use them commercially. The New South Wales Department of Health, however, advises that at a future date the use of borax compounds in food will be prohibited, and therefore considers that permission to use them in the treatment of pineapples should not be given.

(*d*) *Calcium Hypochlorite.*—Consignments of pineapples treated with calcium hypochlorite ("chloride of lime" or bleaching powder), after inoculation with the organism as already described, have demonstrated that it is almost as good as benzoic and salicylic acids in controlling stem-end infection. Calcium hypochlorite rubbed on the stems has the disadvantage of making the appearance of the base of the fruit unsightly, as well as causing some local discoloration. The white residue is, however, easily and quickly washed off under the tap, and we therefore think that those slight disadvantages are amply compensated for by its cheapness and efficiency. The Table shows that, out of a total of 58 pineapples treated with it, two developed stem infection, whereas all controls contracted the disease. Further work must be done with this substance before it can be recommended for general use.

5. Discussion.

Soft-rot of pineapple, known in the local southern markets as water blister, develops between the time of picking and marketing of the fruit during the hot months of the year, usually from January to May. The prevailing temperatures during that period are most favorable to the rapid growth of the causal organism, and consequently the disease develops very quickly. A lower temperature, such as prevails during the other part of the year, only allows very slow development of the parasite, and on this account the disease is then practically unknown. It appears reasonable, therefore, that if pineapples could be sent to the southern markets under cold conditions during the summer months, losses from the disease would be much reduced.

Examination of 1,148 diseased fruit in the Sydney markets during February and March, 1929, revealed that 75.5 per cent. of infection had its origin through the cut surface of the stem, 22.3 per cent. presumably through side wounds, and 2.2 per cent. at or near the junction of the crown with the fruit. Our major effort was, therefore, directed towards finding a fungicide that, applied to the cut surface of the stem, would prevent growth of the organism, and consequently the development of the disease. The results of consignments of fruit, totalling 164, to the cut stems of which benzoic acid was applied up to five and a half hours after inoculation with the conidia of the causal organism, show that this chemical altogether prevents infection through the cut stems, and, therefore, if used commercially, should much reduce the present loss of fruit by disease. As Table 1 shows, tests of salicylic acid have given equally good results, and those of boric acid, borax, and calcium hypochlorite indicate that they reduce materially the amount of disease. Our laboratory experiments on the effects of inoculation of the unwounded surfaces of the fruit lead us to the conclusion that infection seldom, if ever, takes place under those conditions. On the contrary, infection is very readily obtained following inoculation at points where there are growth cracks in the fruit or bruised or cut surfaces. Since our counts of diseased fruit indicate that 22 per cent.

of those infected contracted the disease on their sides, it is reasonable to conclude that infection followed bruising, wounding, or through growth cracks.

Salicylic, benzoic, boric acids, and their compounds are allowed in some countries as preservatives of certain canned and bottled foods and drinks. Their use is, however, looked upon with disfavour. Borax is used in the United States of America in the preventing of rotting of oranges during transportation and storage. In our experiments, the employment of these substances in the prevention of soft-rot of pine-apples has been restricted to the cut ends of the stem. According to the report of chemical analyses presented in this paper, salicylic and benzoic acids have been found to enter only the core of the fruit, and that in minute amounts. None was found in the edible portion of the fruit. However, according to the ruling of the Health Department of New South Wales, pineapples intended for sale in that State may not be treated with any of the hereinmentioned fungicides, except benzoic acid.

6. Control.

Soft-rot of pineapple is of economic importance in Australia during the summer months, when the fruit is ordinarily subject to temperatures around 25°. Laboratory studies of fruit artificially inoculated have shown that the disease develops most rapidly between 23° C. and 29° C., whereas at temperatures below 12° C. there is no evidence of rot, even after seven days. It appears, therefore, that were facilities available for transportation and storage at low temperatures during the summer, the loss from disease would be greatly reduced. The use of refrigator cars, if available, is suggested.

In the absence of adequate facilities for transportation at lower temperatures, the application of certain fungicides to the exterior of the fruit is suggested for the prevention of infection. The results of experiments reported in this paper show that borax, boric acid, or calcium hypochlorite applied to the cut stems is very effective in reducing the amount of infection to negligible proportions. Benzoic or salicyclic acid altogether prevents stem-end infection.

Since the application of these fungicides to the stems has for its object the prevention of germination and subsequent growth of conidia which may lodge there after the picking of the fruit, and as the conidia germinate in about six hours under average summer conditions, it is advised that the selected fungicide be applied within not more than about five hours after the fruit is picked.

As the use of salicylic acid and borax compounds is not viewed with favour by Departments of Health, we do not advise their use commercially. Benzoic acid is recommended. It is best and most economically applied either by brushing the stems with an alcoholic solution of not less than 10 per cent. strength, or by rubbing the stems in a mixture of one part to not more than four parts (by weight) of kaolin.

Infection through the fruit may possibly be somewhat reduced by more careful handling in picking and packing operations. The importance of careful handling with a view to avoiding wounding is emphasized, because every wound is an area of possible infection.

It appears to be uneconomical and perhaps impracticable to immerse fruit for the length of time necessary to insure disinfection of wounds. Methods for the control of side infection that will admit of commercial application have, therefore, yet to be evolved, if possible.

Appendix 1.

REPORT OF ANALYSIS BY NEW SOUTH WALES DEPARTMENT OF HEALTH.

Number in Analysis Register—7846. *Analysis made by R. G. O'Brien. Date—5th February*, 1931.

The samples of pineapple (18) marked or labelled ——— received on 27th January, 1931, from the Chief, Division of Plant and Industry, C.S. & I.R., Canberra, have been examined, with the following results:—

The edible portion of pineapple is usually taken as the fruit flesh freed from the harsh outer skin, and also from the fibrous core. The removal of the latter, however, is not always complete, and consequently the presence of any preservative in the core must be regarded as of some importance.

TANNIC ACID TREATMENT.

In the pineapples submitted, which had been treated with tannic acid, it was possible, by means of staining with dilute ferric chloride solution, to follow the entry of the preservative into the fibres of the core, although no evidence of penetration was visible in the fruit flesh. The following are the details of the tests undertaken in this connexion:—

The pineapples were freed from skin, but were not cored. Sections were cut at intervals from the base of the fruit, and were stained with dilute ferric chloride solution, with the results shown:—

Pineapples Treated with Tannic Acid.

Sample No.	Distance of Section from Base of Fruit.	Result of Test.
	¾ inch	Tannic acid present in core, but absent in fruit flesh
	1¼ inches	" " " " " "
1	2 inches	Very faint indication of tannic acid in core; absent in fruit flesh
	Near top of pineapple ..	Tannic acid still visible in two fibres
2	.. .. ..	Similar results to those obtained with No. 1
3	.. .. ..	Practically no penetration of tannic acid in core; none in fruit flesh
4	.. .. ..	Medium penetration of tannic acid in core, less than in Nos. 1 and 2, but none in fruit flesh
5	.. .. ..	Practically no penetration of tannic acid in core; none in fruit flesh
6	.. .. ..	" " " " " "

From the above results it is seen that the preservative penetrates the core in small quantities to varying depths, depending in all probability on the nature of the pineapple (degree of ripeness, &c.).

PINEAPPLES TREATED WITH SALICYLIC ACID.

Salicylic acid was found to penetrate in a manner similar to that of tannic acid. As, however, the natural acidity of the fruit interferes with the delicacy of the direct test, its course could not be followed with the degree of accuracy possible in the fruit treated with tannic acid.

Three pineapples, the total weight of which was 5.8 lb., deprived of their skins and the ends removed, but uncored, were found to contain salicylic acid in the proportion of 1-100th grain per lb. This was all present in the core, mostly towards the base of the fruit. No evidence of the penetration of the preservative into the fruit flesh was obtained.

PINEAPPLES TREATED WITH BENZOIC ACID.

This preservative was found to behave similarly to salicylic acid, penetrating the core in minute amounts.

Appendix 2.

RULING BY NEW SOUTH WALES DEPARTMENT OF HEALTH.

In reply to your letter of the 26th ultimo with further reference to the above subject, I am instructed to inform you that the consensus of opinion at present in most countries is that use of salicylic acid should be discontinued. This was also agreed upon at the last inter-State and Commonwealth Conference on Food and Drugs.

The existing regulations in this State do allow salicylic acid, but manufacturers are aware that it is only a matter of time before it is prohibited. New regulations will shortly be gazetted whereby the use of salicylic acid will be prohibited after June, 1932.

As benzoic acid appears to be as satisfactory as salicylic acid, it would be preferable to aim at using the former. This Department would not object to use of benzoic acid, but is opposed to salicylic acid, except where no other preservative is suitable for a particular commodity.

The Control of Noogoora and Bathurst Burr by Insects: Report by S. G. Kelly, M.S.

In previous issues of this *Journal* (Vol. 3, 1930, pp. 64, 77, 183) mention has been made of the Noogoora burr problem and of the work an American graduate, Mr. S. G. Kelly, is carrying out in Kansas in connexion with insects that there attack species of the genus *Xanthium*, to which the Australian Noogoora burr and Bathurst burr belong. Mr. Kelly has recently furnished the Council's Division of Economic Entomology with a report on his activities to date. As it is considered that much of the information he has furnished will be of general interest an article has been prepared from his report, and it appears below. A brief summary of the article is as follows:—

Summary.—A search is being made for an insect that will be as effective against the burrs in question as is *Cactoblastis* against prickly pear. The work is being carried out in Kansas, where approximately 75 species of insects have been found to attack *Xanthium*, although only a small proportion of these confine their attention to the weed. There are eight species which are being studied at present.

One insect, a fly (*Euaresta aequalis*), whose maggots feed in the seeds of cockleburrs, has been sent to Australia to be tested under quarantine conditions at Canberra. Evidence from Kansas indicates that this insect is less plentiful in regions of high rainfall and in fields of sandy soil. The life cycle has been changed to fit the seasons of Australia.

Other insects show considerable promise, but will require further testing on plants of economic value before any decisions can be reached as to the advisability of sending them to Australia.

The scope of the work includes (i) the collection, identification, and study of life histories of the various insects attacking *Xanthium;* (ii) a review of the literature on each insect; (iii) a study of the plants the insect will attack, including starvation and oviposition tests on these plants; (iv) studies of parasites and diseases of the insects; and (v) the sending of selected species to Australia, which in turn involves a study of the time and methods of shipping to be used for each variety.

From observations in Kansas, the author believes that the maximum of satisfactory production of burr infestations in Australia will not be reached until four or five species can be released. As yet, however, an immediate release of most of the insects is not desirable, since they first require thorough testing.—ED.

1. Introduction.

Since insects inhibit the growth and spread of species of *Xanthium* in the Americas, studies were begun with the hope of finding one or more varieties which could be successfully and safely introduced into Australia for the control of these weeds. Kansas was selected as the place for the investigations because of its similarity in climate to the regions of Australia where *Xanthium* is most abundant. The writer was chosen to conduct the investigations which were begun as a summer research problem in June, 1929. Since then the work has been expanded, and full time has been devoted to a study of the problem.

The cockleburr plant is a member of the *Compositae* family of plants, and belongs to the genus *Xanthium*. Most of the species are natives of North and South America, but some are considered to be indigenous to Europe(25). In Kansas, where these studies are being made, the most common species occurring is *Xanthium pennsylvanicum*. *X. chinense* also is fairly common in Eastern Kansas.

The plant is recognized as a troublesome weed by all American farmers, but is not considered as an impossible pest to control. It grows best in low places in which native vegetation has been disturbed, and along stream beds where moisture and fertile soil are more abundant, but it also is found occasionally on upland. The competition with other plants for plant nutrients and moisture is negligible as compared with that experienced by many other weeds, but the burrs are a serious pest to farm animals and sometimes to man. The spread of the plants is brought about by means of the burrs which cling to live stock and other carrying agencies. Since they are often carried by flood water, they are found commonly along stream beds. The survival of the plant is further guaranteed by the fact that in each burr there are two seeds, which germinate at different times. It has been found that one seed normally germinates the first year after maturity, while the other usually does not germinate until the second year.

2. Review of Literature.

The amount of literature on *Xanthium* insects is limited, due to the fact that by most workers these insects are not thought to be important. Literature on those *Xanthium* insects which seemed to be of importance in the investigations is reviewed in the following paragraphs:—

1. The cockleburr billbug (*Rhodobaenus tredecimpunctatus* Ill.) was first described by Illeger in 1791. Riley mentioned the occurrence of the insect on *Xanthium* in 1870. Blatchley and Leng(3) stated that it occurs over the United States of America, and that it breeds in the stems of cockleburr, joe-pye weed, leaf-cup, sunflower, thistle, greater ragweed, and rosin weed, and that it hibernates in the adult stage.

They also stated that several varieties of this species have been described on the basis of colour alone. *Rhodobaenus tredecimpunctatus pulchellus* has the spots at the end of the elytra coalesced, but Blatchley and Leng considered that it is scarcely worthy of a varietal name. *R. tredecimpunctatus quinquepunctatus* has the elytra wholly black except a narrow reddish strip along each side. The thorax also has a large portion blackened. They also state that it occurs in southern United States.

Chittendon(6) stated that it has long been known to breed in the stems of *Dahlia,* and there was evidence that it could breed in beet-stalks. A full description of the larvae was given by Chittendon(6), and he gave the distribution as the United States of America, Mexico, Central America, and Colombia, South America.

2. *Baris callida* Casey.

Blatchley and Leng(2) stated that this insect was taken in New York and New Jersey, and the larvae, pupae, and adults were taken on *Xanthium.* Casey(5) gave the full description of the adults in 1892, from specimens collected in Georgia. The insect has not been reported on any plant except *Xanthium.*

3. *Baris xanthii* Pierce was first described by Pierce in 1906. He reared it from roots of *Xanthium* at Dallas, Texas. On 15th August, 1906, he noticed large numbers of adults feeding on the tip stems of cockleburr plants, between the flowers, and concealed in small cells which they had made by feeding. He also found larvae in the roots on 29th August, and pupae in the cells of the roots on 2nd October(19).

No record was found of this insect feeding on plants other than *Xanthium.*

4. *Ataxia hubbardi* Fisher.

A full description of this new species is given by Fisher(8). He stated that it had been confused with *Ataxia crypta* Say, and was found by him in collections along with *A. crypta.* The localities given by Fisher were Arizona, Texas, Oklahoma, Kansas, and Nebraska. It was collected in the stems of *Xanthium, Helianthus,* and *Ambrosia.*

5. *Dectes spinosus* Say.

Leng and Hamilton(11) recorded this insect from Massachusetts, New York, New Jersey, Pennsylvania, Ohio, Louisiana, Texas, New Mexico, Colorado, and Iowa. They stated that it breeds in the stems of *Ambrosia* (probably *A. trifida*), in which the larvae hibernate. The larvae have been found in the stems of *Ambrosia, Eupatorium,* and *Xanthium* in the State of New York.

6. *Hippopsis lemniscata* Fabr.

Leng and Hamilton(12) recorded this insect from New York to southern Florida; New Jersey; Pennsylvania; District of Columbia; North Carolina; Georgia, westward to Texas, and northward to Missouri and Ohio; and Brazil, South America. They stated that it breeds abundantly in the stems of *Melothria pendula,* a climbing cucurbit, at Lake Worth, Florida. The larvae were also found in stems of *Coreopsis* (tickseed), Bidens (burr marigold), and *Ambrosia.*

This insect was not recorded as an insect of *Xanthium* in any of the literature reviewed.

7. *Euaresta aequalis* Loew.

Aldrich(1) listed this insect under the family Trypetidae and gave the first description as having been made by Loew. Marlatt(17) reared the adults from cockleburrs collected at Washington, D.C., in 1899. He found the flies in the cage in September, but the exact date of emergence was not known. In no case did he find more than one larva

in a burr, which accounted for his theory that the germination of the remaining seed aided the fly in its egress from the burr. Phillips(20) recorded the insect from the following States:—New York, Maryland, Indiana, Nebraska, Washington, Virginia, District of Columbia, Pennsylvania, Iowa, Illinois, Ohio, Kansas, Idaho, Colorado, California, and New Mexico.

8. *Apion melanarium* Gerst.

None of the literature reviewed gives a host preference for this insect. Fall(17) recorded it from Massachusetts, Long Island, District of Columbia, Pennsylvania, Canada, Michigan, Illinois, Iowa, Kansas, and Texas. Blatchley and Leng(4) added Florida to the localities in which it had been collected, and stated that it was found at Arlington, New Jersey, from April to October. Smith(21) recorded it from Georgia and Arizona, in addition to other States mentioned above.

9. *Epiblema strenuana* Walker.

Heinrich(9) recorded the synonymy of this insect and gave the type localities of each, all being in the United States of America. He recorded the food plants, which were *Ambrosia trifida,* the greater ragweed, and *Ambrosia artemesiaefolia,* the common ragweed. Forbes stated that it was general in distribution in New York, typical specimens having been bred from *Ambrosia trifida,* while *minutana,* a sub-species, was bred from *A. artemesiaefolia.* Smith(22) recorded this insect as *Eucosma strenuana.* He stated that it is common throughout New Jersey from May until August, the larvae breeding in stems of *A. trifida,* making slender, spindle-shaped galls.

No record was found of the occurrence of this insect on *Xanthium.*

3. Methods.

The methods used in studying the various insects were, in most cases, rather empirical. Since most of the damage by insects is done by the immature forms, the identification of each species was necessarily delayed until adults could be reared. Due to this fact, progress has been impeded in the early stages of the work until the insects could be reared and identified.

At the beginning of the problem a survey was made to determine the species of *Xanthium* occurring in the vicinity of Manhattan, Kansas. Frequent visits have been made to these areas during the course of these studies to determine the insects present. Longer trips were made throughout the period by means of an automobile. The points considered in the study of the insects included the following:—The time each species was most abundant, habits and life history of each, and the parts of the plant the insects were attacking. Laboratory work was conducted with cockleburrs, which were planted for experimental purposes at the field insectary of the Department of Entomology at the Kansas State College.

Insects were collected in the fields from the roots, stems, leaves, flowers, and burrs of cockleburr plants. When immature forms were collected which could not be identified, they were reared to the adult stage in cages. The investigations concerning insects not likely to attack plants of economic value were continued, while studies of those found to be feeders upon valuable plants were discontinued. A record

was kept of each place where collections were made in order to determine the phenologic and edaphic factors which might influence the abundance and distribution of the insects.

4. Insects.

1. *Euaresta aequalis* Loew; Order Diptera, Family Trypetidae.

(*a*) 1929 Studies.

Since it was most desirable to find an insect which would infest the seed, considerable stress was placed on this phase of the work. The writer collected burrs of the 1928 crop in the spring of 1929 and examined them in order to ascertain if any insects were attacking the seeds. Dipterous larvae were found infesting the seeds, and the adults which emerged from them in August, 1929, were identified as *Euaresta aequalis*. A survey trip over an area comprising nineteen counties was made in August, 1929, to determine the distribution of the fly in Kansas. Observations on the trip and subsequent trips indicated that the insect occurs in all parts of Kansas where *Xanthium* is found.

The first fly emerged on 5th August, and adults were plentiful on cockleburr plants after that date until about 15th September. Males were more numerous than females during the first week after the appearance of the flies, while toward the latter part of the season the females appeared to be more plentiful than the males. The first pairs to mate were observed on 19th August. Ovipositions were made in the green burrs when they were fully grown or nearly so, but before they were matured enough to become hardened.

Extensive data were taken on the infestation of burrs by the larvae of *Euaresta aequalis*. Burrs were collected from 21 fields for the purpose of obtaining these data. In making the infestation records, the burrs were cut open so that both seed capsules were exposed to view. This was accomplished by cutting parallel to the long axis of the burr and parallel to a line between the two beaks. The side walls of the two seed capsules were cut away, exposing both capsules by the same cut. A complete infestation record was made of each seed capsule examined. The condition of the lower seed (L), which normally germinates the first year after ripening, was recorded separately from the upper (U), or delayed germinating seed. The seeds which appeared viable were recorded as normal (N), while the dead ones resulting from causes other than insect injury were recorded as dead (D). Those causes were principally abortion or lack of pollination. If the seeds were infested with larvae of *Euaresta aequalis* they were recorded as infested (I). Infestation initials were entered in red pencil in order that summarization might be more easily accomplished. Each month the records were summarized and compiled in tabular form in such a way that the complete condition of each burr was recorded. Subsequently the whole of the data was summarized.

In all a total of 15,988 burrs (corresponding to 31,976 seeds) were examined, this total being made up of examinations carried out in 21 different fields or localities.

Burr infestations varied from 2.8 per cent. to 50.6 per cent., the average for all burrs examined being 26.85 per cent. The burrs with both seeds infested had a maximum percentage of 15.2, a minimum of 0, and an average of 3.92 per cent. The percentage of seeds infested varied from 1.4 to 32.9, with an average percentage of 15.41.

In every case the lower seeds were more heavily infested than the upper seeds, the average percentage for the lower ones being 19.84, while the upper seeds had 11.07 per cent. infestation. The choosing of the lower seeds for infestation may be a matter of choice due to the relative position of the seeds rather than selection. The surface of the capsule enclosing the lower seed is more exposed, therefore, the insect is more likely to alight there for oviposition. However, further investigations will be necessary before definite proof can be shown. The burrs are so arranged on the plant that the upper seed is next to the axil formed by the stem and burr. From casual observations, it seems that this arrangement does not hold true when there are several burrs in one cluster; in such cases, oviposition is likely to occur in either capsule.

Many seeds were found dead due to other causes. These causes may have involved several factors, such as lack of pollination, abortion, or injury by *Euaresta aequalis* when the seeds were very young, the larvae dying before they attained sufficient size to be recognized. The average percentage of dead lower seeds was 23.83, while the percentage of dead upper seeds was 20.1 per cent. These dead seeds increased the percentage of unviable seeds. The unviable seeds from the different fields varied from 8.1 to 63.45 per cent., and the average for all seeds examined was 37.58 per cent.

An attempt was made to determine the factors affecting the abundance of the insects in the different localities where the collections were made. A record was kept of the species of *Xanthium* collected from each field. The rainfall records obtained from a climatological sheet compiled by the State Meteorologist of Kansas were found to be of value in collecting data. Those fields with the lowest infestations were composed of sandy soil. In every case, burrs from sandy soil had low infestation. This may be explained by the fact that flies of the family Trypetidae do not favour the high temperatures of such soils.

Another factor which seemed to affect the distribution was the amount of rainfall. By comparison of infestations in fields of silt loam it was found that those burrs which came from counties of the least rainfall had higher infestations. For example, Anderson County, Kansas, which has an annual rainfall of 36 inches, had 17.6 per cent. infestation; while Ellsworth County, with rainfall of 26 inches, had 50 per cent. infestation in burrs from the same type of soil. Other comparisons can be made to demonstrate this correlation.

X. pennsylvanicum and *X. chinense* were both found in field number 12. The former had a much higher percentage of infestation. An attempt will be made to find other fields which contain both species in order to make other comparisons.

It was necessary to change the life history of the insects to fit the seasons of Australia, which are opposite from those in the United States of America. In Kansas, the adults emerge during August and September while burrs are being formed. It was necessary to change the time of emergence to March or April, which is the time burrs are formed in Australia. A small consignment of infested burrs which had been subjected to a cold shock in November was sent to Australia on 5th December, in the hope that the insects would emerge at the time of burr formation. In the following April, advice was received from Canberra that adults of both sexes had emerged coincident with burr formation in the quarantine insectary. It seemed that they had received the cold

shock and the necessary heat units of the Australian summer to cause them to emerge at the right time. Accordingly, all future consignments are to be sent in December after the larvae have been subjected to a cold shock.

The infestations of burrs in Kansas gave the hope that the insect would be invaluable in Australia if sent without parasites or disease. No parasites were found attacking the insect, but a fungus was found associated with some dead larvae while infestation counts were being made. The death of the larvae may have been caused by either the fungus or low temperatures, but the exact cause was not discovered.

(*b*) 1930 Studies.

Oviposition tests were made in August, 1930. Twenty-five flies were placed in confinement with burrs of *Datura* and *Centhrus,* and no indications of oviposition resulted. Flies were also tested on sunflower (*Helianthus*) and strawberry. No ovipositions resulted. Also, the proboscis of the fly was too weak to penetrate the epidermis of ripe strawberries, although it would feed on the juice after the skin was broken. The fact that the proboscis is weak is proof that the adults will not harm plants in Australia by feeding on them.

Infestation counts of burrs for 1930 showed that most of the counties where burrs were collected had less infestation by *Euaresta aequalis* than in 1929. Unusually high temperatures occurred in Kansas during the summer of 1930, which may have caused a high rate of mortality in the larvae. Two fields had as heavy an infestation as in 1929, although the general infestation by *E. aequalis* over the State was less than in 1929. The two fields were heavily infested with other weeds as well as cockleburr, making the ground heavily shaded during the hot weather. This condition may have been influential in producing a greater number of flies for oviposition than in fields where the surface soil was more easily heated.

No burrs of the 1930 crop were collected from sandy areas because the records of 1929 crop indicate that such areas have burrs with less infestation.

A comparison of the infestation counts for 1930 did not reveal the cause for differences in infestation percentages of burrs from different counties as distinctly as those of 1929. However, the two counties having the highest infestations, Ellsworth and Kearney, have a low annual rainfall.

The burrs from Kearney County were collected near the shore of a large irrigation lake, which may have had some influence on the insects, causing the slightly higher infestation.

All of the infestation counts were made with burrs which were clinging to the plants at the time they were collected. Since many of the burrs fall soon after ripening, it was thought that there might be a difference in infestation between those which fall easily and those which cling to the plants. This would make a difference in the way the insect was spread, and might determine the rate of dispersal. Those which fall to the ground are spread by water, and those which cling to the plants are spread by animals in most cases.

An attempt was made to determine whether the infestation of *E. aequalis* had any effect on the abscission of the burrs. Burrs were collected which had fallen to the ground in the field at Manhattan,

Kansas, and at the same time burrs were collected which were clinging to the plants. Upon examination of 500 burrs from each group, it was discovered that there was very little difference in *E. aequalis* infestation. The burrs collected from the plants had 22.4 per cent. infestation, while those which were lying on the ground had 21.4 per cent. infestation. Since the difference was so slight, the results indicate that the larvae have little or no effect on the abscission.

It seemed that this insect was well worthy of consideration for introduction into Australia, especially as it has never been recorded from any other genus of plants. Since the time for the emergence coincides exactly with the time of burr formation, it seems reasonable to assume that the insect attacks only *Xanthium,* and since it attacks different species of the genus, it would be a valuable insect for the purpose.

It is possible that the work of a single insect, such as *E. aequalis,* will not be appreciated until a number of auxiliary species are introduced.

2. *Epiblema strenuana* Walker; Order Lepidoptera, Family Olethreutidae.

Larvae of this insect were found in galls of *Xanthium* plants in July, 1929. It was discovered that a first generation causes galls to form in the stems of *Xanthium.* The first generation does not harm the plants a great deal, but a few of the plants break at the place where the gall is formed. The adults emerge in August and lay eggs for the second generation. The larvae become full grown in September and hibernate in the stems. They pupate in May, and the adults emerge in early June and lay eggs for the first generation. The larvae of the second generation do not cause galls to form, but make tunnels in the stems, causing the plants to weaken. No plants have been found which were entirely killed by this insect, but, by comparing with adjacent plants which were not attacked, it could be seen that the number of burrs formed was greatly reduced. The maximum damage to the plants occurs when the burrs are becoming mature. From observations made in September, 1930, it appeared that plants badly attacked bore about one-fifth as many burrs as they would have without the infestation.

This insect is a very promising insect for two reasons. At least four species of parasites are common in the larvae, and if introduced without parasites it should multiply rapidly. The second reason is that the insect presents a massed attack on the plants, as many as twenty larvae having been found on one plant.

This insect has been found in cockleburrs in all parts of Kansas where visitations have been made, although it is more common in certain fields. It has been found to be plentiful in Ellis, Rush, Barton, Ellsworth, and Riley Counties.

Tests are to be made in 1931 to determine if this insect attacks other plants. *E. strenuana* has been reared from larvae found in the stems of ragweed (*Ambrosia*), but no evidence has been found which indicates that it will attack plants of economic value.

It seems that the best time for shipping this insect to Australia, providing it passes the oviposition and starvation tests, would be from November to January. The larvae would arrive in Australia during

the warm season, and a brood of moths could be expected to lay eggs for at least one summer brood. Acclimitization of *Epiblema strenuana* may not be as easy as it is with *Euaresta aequalis.*

3. *Rhodobaenus tredecimpunctatus* Ill.; Order Coleoptera, Family Curculionidae.

The life history and habits were studied during the summer of 1929, and are as follows:—

The adults hibernate in stems of cockleburr plants and become active in the fields during the latter part of May. The adults damage young plants by splitting the stems for the purpose of feeding and egg-laying, damaging the plants to such an extent that they sometimes die from the attacks. Mating and oviposition are common from 10th June until 1st July. The larvae become full grown and pupate about 25th July, emerging about ten days later. The greatest number of adults of the 1929 brood appeared about 10th August, and since oviposition was most common on 15th June, the time for development from egg to adult appeared to be approximately eight weeks. The adults feed on the tender portions of the plant until cool weather begins, then hibernate.

The injury to large plants by the larvae is not very effective, but plants less than 8 inches tall can be killed. The larvae bore near the centre of the stems, and therefore do not cause appreciable injury to large stems.

Oviposition tests were made in the summer of 1930 with this insect put in cages with sunflower, artichoke, garden beets, and aster. All such tests were negative, but the adults fed readily on all the plants. Collected larvae were placed in stems of sunflower, artichoke, and ragweed. They fed on the stems, and one specimen was reared to the adult stage on sunflower. The rest of the larvae died, probably because of severe hot weather.

The writer noticed an interesting host selection by the two common forms of the insect. The variety *pulchellus* was commonly found on cockleburr, while typical specimens of *R. 13-punctatus,* with thirteen distinct spots, were found on sunflower. A record was kept of the host selection of each form, and among over 400 specimens collected, only six were found to be exceptions to the correlation.

Very little work will be done with this insect in the future, since it appears that an introduction into Australia might result in the destruction of valuable plants.*

4. *Baris callida* Casey; Order Coleoptera, Family Curculionidae.

Although small, this insect may prove to be one of the most valuable after introduction into Australia, since it occurs only on *Xanthium.*

The adults hibernate in small pockets in the roots. The eggs are laid, probably on the roots, some time in June. The larvae bore into the roots, performing most of the burrowing immediately beneath the bark of the root. As many as eleven larvae have been found on one root. The plants are weakened to a varied extent, according to the number of larvae present and the size of the plants. The writer has seen plants large enough to bear 500 burrs which were entirely killed by the larvae before any burrs were matured. The larvae make small

* The Chief of the Division of Economic Entomology has already decided not to recommend that this insect should be introduced into Australia.—ED.

pockets in the roots and pupate in September. The adults emerge in September and October, many of them remaining in the cells through the winter. Others come out and feed on the tender portions of the plant, near the base of the green burrs, some burrs being pruned off by their feeding.

One species of parasite is fairly common on *B. callida* in Kansas. If introduced without the parasite, *B. callida* may increase to sufficient numbers to be of value while working in conjunction with other insects. Negative oviposition and starvation tests were obtained with the adults on *Ambrosia, Helianthus,* and *Aster.*

5. *Baris xanthii* Pierce; Order Coleoptera, Family Curculionidae.

The habits and life history of *Baris xanthii* are nearly identical with those of *B. callida.* The adults of *B. xanthii* are found in larger numbers in September and October at Manhattan, and prune off more of the green burrs than does *B. callida.* The overwintering quarters of *B. xanthii* have not been discovered, but it is evident that it hibernates in the adult stage. Adults are found in the fields in June, and larvae are found on the roots during July and August, pupation occurring in August and September.

A count was made in a plot of *Xanthium* plants on 14th August in an area where this insect was prevalent. Two hundred and fifty-two plants were counted; 18 per cent. were alive, 47 per cent. were entirely killed by this insect, and 35 per cent. were dead due to other causes (chiefly attacks by Cerambycidae larvae). The place was visited after the burrs had matured on the plants. Some of the plants which were alive on 14th August had died in the meantime and only a few plants bore mature burrs. An examination was made of the burrs, and the results showed that there were not enough viable seeds produced on the plants in the area to reproduce as many plants for 1931 as grew in the area in 1930.

One species of parasite was reared from the larvae, which gave the hope of multiplication of *B. xanthii* if sent to Australia.

Baris xanthii was not found on any plants other than *Xanthium,* and attempts to get it to feed on sunflower failed.

6. *Apion melanarium* Gerst.; Order Coleoptera, Family Curculionidae.

Small larvae of *Apion melanarium* cause galls to form in the stems of *Xanthium.* The plants are weakened to some extent, and the insect may prove to be a good auxiliary insect if introduced into Australia. The adults feed on the tender portions of the plant and inflict some injury.

Only a small number of specimens have been collected; therefore, no tests have been made to ascertain if the insect is specific on *Xanthium.* One parasite was reared from the larvae.

7. *Hippopsis lemniscata* Fabr.; Order Coleoptera, Family Cerambycidae.

This insect has not been found to be very plentiful in Kansas, but searches are being continued with the hope of finding an area where it is present in large numbers.

The adults appear in June and oviposit in the stems. The larvae develop slowly and attain full size in August and September. All plants are weakened by the attack, and a large percentage die without producing seed. The larvae have a pruning habit which is valuable in the destruction of *Xanthium*. The plants are pruned about 1 foot above ground at the time the burrs are becoming mature. Although some burrs mature before the pruning occurs, many of them are pruned before they have developed viable seeds. The larvae hibernate in the lower part of the stem, pupate in the latter part of May, and emerge as adults in June. Specimens of a species of parasite were reared from the larvae of this insect.

8. *Dectes spinosus* Say; Order Coleoptera, Family Cerambycidae.

This insect is fairly common on *Xanthium* and *Ambrosia* in eastern Kansas. The life cycle is the same as *Hippopsis lemniscata*, mentioned above. The larvae bore in the upper portions of the stems during the time of burr formation, and many burrs die before becoming mature. The larvae prune the plants near the surface of the soil when cold weather comes in November and hibernate in the roots.

Oviposition tests were negative when the adults were tested on artichoke. No starvation tests have been made with the larvae because they have not been found in sufficient numbers.

One parasite is common on the larvae. In Republic County, Kansas, birds were found to feed on the hibernating larvae after tearing the stub apart.

9. *Ataxia hubbardi* Fisher; Order Coleoptera, Family Cerambycidae.

This insect has not been found in the vicinity of Manhattan, but was found to be very plentiful in Graham County, Kansas. Since it occurs in the more arid regions, it is recognized as a very promising insect, because of the similarity in climate to the regions of Australia where *Xanthium* is abundant. The life cycle is the same as the other two Cerambycidae mentioned above. The larvae hibernate in the lower portion of the stems, but do not prune. The amount of injury done to the plants by the larvae is remarkable. A large number of plants were entirely killed in an area which was visited in Graham County in October, 1930. Adjacent plants which were not infested had as many as 400 burrs.

The larvae were heavily infested by a Hymenopterous parasite. This fact gives the hope that it would increase to valuable numbers if introduced into Australia without its parasites. Larvae have been collected and oviposition and starvation tests are to be made in the summer of 1931.

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The Apparent Effect of Mallee Scrub in Causing Frosts.

By E. S. West, B.Sc., M.S., Officer in Charge Commonwealth Research Station, Griffith.

In the report that follows, figures are given which lend support to the view that the so-called "Mallee scrub" exerts no little effect in causing frosts or in intensifying them in its immediate neighbourhood. The facts supporting that conclusion are by no means complete, but as one of the results of the publication that follows, it is hoped that other evidence, either for or against, may be forthcoming. If mallee scrub does attract or intensify frosts, such information is obviously of considerable economic value to those whose duty it is to lay out closer settlement schemes in which the crops to be grown are likely to be damaged by frost, as for instance vines.

Thanks are expressed to the Water Conservation and Irrigation Commission of New South Wales for making available fifty minimum thermometers, which made the investigation possible, and for assistance given by some of the officers of the Commission in reading thermometers in certain localities where otherwise it would have been difficult to obtain regular readings.—ED.

Inquiry into the causes of unusually severe frosts that occur in certain localities on the Murrumbidgee irrigation areas, New South Wales, led to the suggestion that the dense mallee scrub near these localities may in some way be responsible.

Mallee scrub consists of various species of the genus *Eucalyptus*, principally *E. dumosa* and *E. olliosa*, which have a peculiar and characteristic habit of growth, in that several stems arise from one root stock. The stems are bare of foliage except near the top, where they branch out, forming a canopy of foliage eight to ten feet high. The leaves of eucalypts being pendulous and turning their edges to the sun, they throw little shade, and this is particularly true of mallee. Nevertheless, from a distance the scrub appears dense and dark, and one is lost from view a chain or two within it. (See Plate 3.)

Reference to the possible effect of forest on minimum temperatures is very scanty. Bailey,* in discussing frost, says, "A frequent case is this —A strawberry field is on a gentle slope, and on the upper side is a wood. In time of frost the only injury occurs in a belt two or three rods wide just against the wood." Hume† also mentions cases of increased frost injury near belts of timber. On the other hand, Pearson‡ found higher minimum temperatures in a forest than in an open space.

The problem was studied on the Murrumbidgee irrigation areas by exposing minimum thermometers in portable shelters which were themselves placed in selected localities within and without the mallee scrub. These shelters, which were standardized, consisted of two pieces of rough sawn timber 18 inches long by 9½ inches wide by 1 inch thick, painted a flat white, nailed together along their long edges to form an inverted L in cross-section, and screwed to a hardwood stake. When in position,

* Bailey. "Principles of Fruit Growing" (MacMillan Co., 1920), p. 50.

† Hume. "The Cultivation of Citrus Fruits" (MacMillan Co., 1926), p. 224.

‡ Pearson. "Monthly Review." Reviewed in *Quarterly Journ. Roy. Meteor. Soc.*, **40**: 166-168, 1914. (London, 1913.)

the bulb of the thermometer was 1½ inches from the vertical board, 2¼ inches below the horizontal board, 4½ inches within the sides of the boards, and 1 metre from the ground.

Fifty thermometers were available, and these were exposed in one set of localities until minimum readings had been obtained for about six clear calm nights; whether a frost was actually recorded or not was considered immaterial. When sufficient information had been thus obtained, the thermometers were removed to a new set of localities.

Lake View Area.

A heavy belt of mallee scrub about 5 miles long by about 5 miles wide occurs at Lake View. Three-quarters of a mile north of this belt, another large belt occurs, which, in fact, is connected with the first by a tongue of mallee scrub.

The following shows the mean minimum temperatures after seven calm, clear nights in a line of thermometers commencing three-quarters of a mile within the scrub and extending to 3½ miles outside the scrub*. The position of this line of thermometers was chosen so that the effect of contours would be as small as possible.

Table 1.

Location.	Mean Minimum Temperature.
¾ mile within scrub	29·3
½ mile within scrub	29·6
¼ mile within scrub	28·0
Edge of scrub	30·8
¼ mile without scrub	32·0
½ mile without scrub	33·0
¾ mile without scrub	33·7
1·7 miles without scrub	35·0
2¼ miles without scrub	35·6
2¾ miles without scrub	34·2
3½ miles without scrub	34·6
Standard error of mean difference ..	0·340

The minimum temperatures outside the scrub are about 6 degrees higher than those within it. From the edge of the scrub, the minimum temperatures increase progressively up to the station 1.7 miles outside, and the influence of the mallee appears to be felt three-quarters of a mile away from it. The minor irregularities are due to local conditions other than the mallee.

* In all cases the temperatures recorded in this report are in degrees Fahrenheit.

The following table summarizes the mean minimum temperatures of 38 thermometers taken after seven calm, clear nights exposed within and to the south of the mallee at Lake View:—

TABLE 2.

Location.	Number of Stations.	Mean Minima.	Extreme Mean Minima.	
			Lowest.	Highest.
In scrub	3	28·9	28·0	29·5
From edge to ¼ mile from mallee on level ground or bottom of slope ..	8	31·5	30·1	32·6
From edge to ¼ mile from scrub on rise	4	33·6	30·9	34·1
¼–½ mile from scrub	10	33·3	32·0	34·1
¼–½ mile from scrub on rise	4	34·7	34·5	35·1
Over ½ mile from scrub in hollows ..	3	33·9	33·6	34·1
Over ½ mile from scrub on level country	5	35·2	34·6	35·6
Standard error of mean difference .. 0·340				

The standard error refers to the mean differences between compared stations on any particular nights, and indicates the reliance which can be placed on the differences between the means of any two stations.

In the third column, the means of the mean minimum temperatures of the several stations in the groups described in column 1 are given, and as a standard error of these means based on so few stations would be somewhat meaningless, the extreme mean minima, i.e., the highest and lowest mean minima in these groups, are given.

None of the stations in the mallee scrub record as high as the lowest station outside it. The stations furthest from the mallee show the highest minimum temperatures. Super-imposed on this, the stations on rises are warmer than those in hollows. Inside the mallee, the minimum temperatures were on an average 6.3°F. below the minimum temperatures at stations more than three-quarters of a mile outside.

In Table 3, the mean minimum temperatures of 31 stations situated within the mallee and outside the mallee in an area to the south-east of this belt of scrub are summarized.

TABLE 3.

Location.	Number of Stations.	Mean Minima.	Extreme Mean Minima.	
			Lowest.	Highest.
Bottom of slope in mallee	2	31·6	31·5	31·6
On level ground in mallee	4	32·5	31·5	33·2
On rise in mallee	2	34·6	33·3	35·9
From edge of mallee to ¼ mile from mallee	3	34·2	34·0	34·4
From edge of mallee to ¼ mile from mallee on rise	1	36·4	..	..
Over ¼ mile from mallee in hollows ..	4	37·1	36·6	38·0
Over ¼ mile from mallee on rather level ground	7	37·5	36·0	38·9
Over ¼ mile from mallee on rises ..	5	38·6	37·0	39·2
Standard deviation of mean differences .. 0·450				

The same general relationships are seen in this Table as in the previous ones.

Particular mention may be made of a station on the top of a ridge 20 feet high in the mallee, whose mean minimum was 35.9 compared with a station well outside the mallee at the bottom of a slope of 30 feet and the centre of the drainage of the surrounding country with a mean minimum of 36.6°F. That is, the influence of the mallee scrub has quite swamped the influences of the contours.

Table 4 summarizes the results obtained from 33 stations distributed through both belts of mallee at Lake View and through the open country between these belts after five clear, calm nights:—

TABLE 4.

Location.	Number of Stations.	Mean Minima.	Extreme Mean Minima.	
			Lowest.	Highest.
In mallee	9	29·3	27·0	30·8
From edge of mallee to ¼ mile from mallee	18	31·0	30·2	32·3
More than ¼ mile from mallee ..	6	33·2	32·4	34·3

Standard error of mean differences .. 0·364.

In this case the country is relatively flat.

A very definite relationship between the minimum temperatures and the presence of mallee is again apparent. In fact a critical study of the eighteen stations included in the group within a quarter of a mile of the mallee scrub emphasizes this, as in all cases, thermometers placed near the mallee register lower temperatures than those placed further away but within the quarter-mile limit.

On the Lake View to Tabitta road, two small patches of uncleared mallee scrub occur, each of 100 or so acres in extent.

Table 5 summarizes the results of readings of sixteen thermometers after six calm, clear nights:—

TABLE 5.

Location.	Number of Stations.	Mean Minima.	Extreme Mean Minima.	
			Lowest.	Highest.
In or near the mallee	9	44·7	43·4	45·8
Away from the mallee	7	46·8	46·3	47·3

Standard error of mean differences .. 0·191.

The mallee is on higher land than the neighbouring open country, but nevertheless the minimum temperatures are lower in or near the scrub than in the lower-lying open country.

A similar study of minimum temperatures in and near mallee, at Yenda, also leads to the same results, viz., that lower minimum temperatures are experienced on calm, clear nights in or near the mallee scrub than further away from it.

A line of thermometers placed across an open space about 1½ miles long and half a mile wide also supports this conclusion. The country is fairly level, the very slight fall, in fact, is towards the centre of the open space.

The mean minimum readings after six calm clear nights were as follows:—

TABLE 6.

Position of Station.	Mean Minimum Temperature.
16 chains within mallee on western side	38·3
Edge of mallee on western side	40·5
16 chains from western boundary (approx.)	42·6
30 chains from eastern boundary	
24 chains from western boundary (approx.)	42·6
22 chains from eastern boundary	
Edge of mallee on eastern side, on tip of tongue of mallee protuding into open space	41·5
Edge of mallee on eastern side, 9 chains east of above, in open pocket intruding into mallee	39·7
18–27* chains within mallee on eastern side	40·1
42–51 chains within mallee on eastern side	39·8
Standard error of mean differences .. 0·164.	

The temperatures become increasingly higher as the centre of the open space is approached.

Discussion.

The data here cited clearly indicate that lower temperatures are experienced on calm, clear nights near mallee scrub than in the open country. Other data obtained would indicate that this is due to the mallee vegetation itself, and not, for example, to the soil type.

It is expected that a large area of the mallee at Lake View will be cleared in the near future. If this is the case, there will be an opportunity of obtaining confirmatory evidence by again exposing thermometers at sites in the cleared portion, in the uncleared portion, and in the original open country, where the readings detailed above were taken, and of ascertaining the effect of the removal of the mallee. It will then be possible, it is hoped, to report these data in greater detail.

*I.e., 27 chains from tip of tongue of mallee protruding into open space and 18 chains from open pocket intruding into mallee.

The Longevity of the Conidia of certain Fungi (*Peronosporales*) under Dry Conditions.

By H. R. Angell,[1] *B.Agr.Sc., Ph.D., and A. V. Hill,*[2] *B.Sc.Agr.*

The article that follows is of interest in connexion with the control of certain fungal diseases of plants, and in particular, blue mould of tobacco. For those who are not conversant with botanical phraseology, it may be explained that "conidia" is the term used to denote one kind of spore of certain groups of fungi, and it is by means of these "conidia" (which, in effect, function like seeds, in that they may germinate and produce new plants) that the fungi, and consequently the diseases such fungi cause, are spread during the season. It has long been known that extreme weather conditions, for example, heat and dryness, can destroy conidia. The work described in the article, however, indicates that the conidia of certain species of a family of fungi (the Peronosporaceae) may be able to survive these extreme conditions to a certain extent, whereas previously it was thought that related species were unable to do so for more than a few hours. This survival is of no little practical importance, in that one species of *Peronospora* gives rise to the dreaded downy mildew or blue mould disease of tobacco. As also brought out in the second article (commencing on page 181), conidia of this particular fungus have been found to remain alive for long periods, and under widely differing adverse conditions. In the case of tobacco, this evidence thus points to the importance of destroying diseased plants (and thus conidia) after the crop is harvested, as well as wild hosts, self-sown plants, and diseased seedlings.—Ed.

1. Introduction.

In the course of a series of experiments on the influence of temperature and humidity on the viability of the conidia of the species of *Peronospora* causing the downy mildew (blue mould) of tobacco, we tried the effect of desiccation over calcium chloride, with the unexpected result that, at room temperature (16-18° C.) the conidia retained their viability for a much longer period (35 days) than under the ordinary room humidity, or in a saturated atmosphere. After confirmation of the results obtained with the tobacco *Peronospora,* we tried the same experiments with *P. parasitica* from cabbage, a species of *Peronospora* from rhubarb, and *Bremia lactucae* from lettuce, and, as may be seen in the following pages, the conidia of some of these species also remained viable for some days under desiccation. The coming of winter and the lack of glass-house facilities for maintaining the supply of diseased plants, has prevented the continuation of the experiments. Consequently, the results given in this paper are of a preliminary nature, and should not be regarded as tending to any other conclusion but that the conidia of some species of the *Peronosporales* are able to remain viable for some days, not only under moist conditions, but also when desiccated. Our experiments on the tobacco *Peronospora*[3] also seem to indicate that at some temperatures the life of conidia under desiccation may be longer than in ordinary humidity or in an atmosphere saturated with water vapour. Other workers have claimed that the conidia of certain species of *Peronospora* and related genera, are short-lived under dry conditions. Lack of material has prevented the extension of our studies to the species with which they worked.

(1) Senior Plant Pathologist, Division of Plant Industry, C.S.I.R.

(2) Assistant Plant Pathologist, Australian Tobacco Investigation.

(3) See page 181.

2. Experimental Methods and Results.

Diseased cabbage, rhubarb, and lettuce plants were collected from a market garden in the vicinity of Canberra, and the conidia were transferred in the laboratory directly to glass slides by gently applying the slides to the lesions. The slides were immediately afterwards placed over calcium chloride in desiccators, in glass vessels, at the humidity of the room or incubators, or in moist chambers. The vessels were then transferred to incubators, to the refrigerator (at 4° C.), or left on the laboratory desk, where the temperature was 16-18° C., or thereabouts. Slides were taken at the intervals given in the tables, drops of water were added, the slides were placed in moist chambers in the laboratory, and examined for germination after 24 hours.

Conidia of Peronospora parasitica.

Percentage of Germination after Storage under given Conditions of Temperature and Humidity.

Temp.	Relative Humidity.	Germination after—				Remarks.
		1 day.	4 days.	11 days.	19 days.	
0° C. ..	..	Not tested	80%	70%	1%	Checks with fresh conidia gave 80% germination at the beginning of the experiment on 30th April. In other experiments a trace of germination was obtained after 10 days desiccation at 2° C. and 16–18° C. also
4° C. ..	60–80%	,,	20%	None	None	
,, ..	Desiccator	,,	60%	,,	,,	
16–18°C.	100%	,,	30%	,,	,,	
,,	60–70%	,,	50%	,,	,,	
,,	Desiccator	,,	5%	,,	,,	
24° C.	100%	,,	60%	,,	,,	
,, .	70–80%	,,	None	,,	,,	
,,	Desiccator	,,	,,	Trace	,,	
28° C.	100%	None ..	,,	None	,,	
,,	30–45%	45% ..	50%	,,	,,	
,,	Desiccator	30% ..	Trace	2%	,,	

Conidia of Peronospora from Rhubarb.

Percentage of Germination after Storage under given Conditions of Temperature and Humidity.

Temp.	Relative Humidity.	Germination after—				Remarks.
		1 day.	4 days.	11 days.	19 days.	
0° C.	..	Not tested	10%	Trace	None	Checks with fresh conidia gave only a trace of germination on 30th April. It is probable that had a sample with greater and more uniform initial viability been obtained, these results would have corresponded with the others
4° C.	60–80%	,,	,,	,,	1%	
,, ..	Desiccator	15% ..	Trace	,,	None	
16–18°C.	Sat. ..	Not tested	None	None	,,	
,,	60–70%..	,,	2%	,,	,,	
,,	Desiccator	,,	None	,,	,,	
24° C.	Sat. ..	,,	,,	,,	,,	
,,	70–80%..	,,	2%	,,	,,	
,,	Desiccator	,,	None	,,	,,	
28° C.	Sat. ..	10%	,,	,,	,,	
,,	30–45%..	None ..	,,	,,	,,	
,,	Desiccator	,, ..	,,	,,	,,	

Conidia of Bremia lactucae.

PERCENTAGE OF GERMINATION AFTER STORAGE UNDER GIVEN CONDITIONS OF TEMPERATURE AND HUMIDITY.

Temp.	Relative Humidity.	Germination after—				Remarks.
		1 day.	4 days.	11 days.	19 days.	
0° C. ..	..	Not tested	80% ..	60%	4%	Checks with fresh conidia gave 70% germination on 30th April. In other experiments 1% germination was obtained after 35 days, desiccation at 2° C., after 17 days at 60–70% R.H. and 70% after 10 days at 2° C. and 60–80% R.H.
4° C. ..	60–80% ..	,,	Trace ..	None	None	
,, ..	Desicc. ..	,,	Not tested	,,	,,	
16–18° C.	100% ..	,,	3% ..	,,	,,	
,,	67–70% ..	,,	5% ..	,,	,,	
,,	Desicc. ..	,,	5% ..	1%	,,	
24° C.	100% ..	,,	None ..	None	,,	
,,	70–80%	,,	2%	,,	,,	
,,	Desicc. ..	,,	10% ..	1%	,,	
28° C.	100% ..	None ..	None ..	None	,,	
,,	30–45% ..	30% ..	5% ..	,,	,,	
,,	Desicc. ..	15% ..	Trace ..	1%	,,	

Conidia of Peronospora from Tobacco.

PERCENTAGE OF GERMINATION AFTER STORAGE UNDER GIVEN CONDITIONS OF TEMPERATURE AND HUMIDITY.

Temp.	Humidity.	1 day.	2 days.	4 days.	6 days.	7 days.	13 days.	Remarks.
4° C. ..	Sat. ..	50%	..	..	..	..	..	Checks with fresh conidia at beginning of experiment gave 50% germination
,, ..	60–80%	50%	2%	50%	50%	50%	..	
,, ..	Desicc.	50%	50%	2%	Trace	Trace	..	
16–18° C.	Sat. ..	25%	10%	Trace	1%	Not tested	..	
,,	60–70%	50%	Trace	,,	None	None	..	
,,	Desicc.	None	,,	None	Trace	,,	Trace	
24° C.	Sat. ..	25%	,,	Trace	,,	..	..	
,,	,, ..	10%	5%	1%	None	Trace	..	
,,	Desicc.	5%	Not tested	25%	Trace	..	..	
28° C.	Sat. ..	5%	None	None	None	..	..	
,,	Desicc.	None	5%	..	Trace	None	..	

3. Discussion.

The results of the experiments presented in this paper are of interest in that they demonstrate that, whereas the conidia of certain other species of the *Peronosporales* have been assumed to be short-lived under dry conditions, those of the species with which we have worked are capable of remaining viable for relatively long periods desiccated over calcium chloride. Whether or not the same holds true of other species, we have not been able to determine because of lack of material. At laboratory temperature (16-18° C.), we have been able in one series of experiments to obtain germination of the conidia of the fungus causing downy mildew (blue mould) of tobacco after they had been kept desiccated for five weeks. On account of the extreme variability in viability

of freshly-gathered conidia, we hesitate to draw conclusions regarding the influence of desiccation on the viability of conidia as contrasted with the ordinary humidity of the laboratory or a saturated atmosphere. We may state, however, that in none of eight series of experiments have we been able to obtain germination after a longer storage period of nine days under the ordinary conditions in the laboratory, or after fifteen days in a humid vessel kept at the same temperature.

Although the results of the experiments on desiccation may not be of direct practical interest, since such dry conditions do not obtain in nature, they suggest that there may be certain conditions under which the viability of conidia may be longer than was previously thought possible. If that period be even a few days, it suggests the great importance of destroying diseased seedlings, over-wintering plants, and wild hosts, all of which produce large numbers of conidia which, after detachment may be carried in the air, or by other agencies, serving to infect seed-beds and fields that may be miles away.

4. Conclusions.

The conidia of *P. parasitica, Bremia lactucae,* and *Peronospora* species on rhubarb and tobacco may remain viable for days, and even weeks, not only when under moist conditions, but also when kept in a desiccator over calcium chloride.

Blue Mould of Tobacco: Longevity of Conidia.

By H. R. Angell,[1] *B.Agr.Sc., Ph.D., and A. V. Hill,*[2] *B.Sc.Agr.*

1. Introduction.

In the course of our investigations of the downy mildew (blue mould) of tobacco, we have observed cases of infection of isolated seed-beds that could not be explained except on the basis of conidia borne through the air, or by other agencies. The climatic conditions prevailing at the time suggested that the conidia were able to withstand extremes of temperature and humidity for a longer time than was previously thought possible. Consequently, these studies were undertaken.

In the literature, we have not been able to find any references to sustained retention of viability of conidia of species of the *Peronosporales* under dry conditions. All writers seem to agree that they lose their vitality except when kept in a moist atmosphere. It is, therefore, interesting to note that the conidia of the fungus causing downy mildew of tobacco remained viable for days (in one experiment for five weeks) over dry calcium chloride in desiccators, for two months in the cool moist air of a refrigerator, and for the same period in cool dry soil.

(1) Senior Plant Pathologist, Division of Plant Industry C.S.I.R.
(2) Assistant Plant Pathologist, Australian Tobacco Investigation.

2. Influence of Temperature and Humidity on Longevity.

Materials and Methods.

A General Electric Company's refrigerator, and Hearson and Baird, and Tatlock incubators, provided the necessary range of temperatures. Commercial fused calcium chloride in flakes, supplied by the British Drug Houses Limited, was used in the ordinary type of desiccator to obtain low relative humidity. Ordinary dry, sandy soil in a cardboard container was used in one series of experiments. In it, slides with conidia on them were buried. On removal for testing germination, the slides were gently tapped to get rid of superfluous particles of soil.

Conidia were transferred to microscope slides from lesions by gently bringing the two in contact, by tapping lesions held over slides, or by transferring with a platinum needle. The slides were then placed over calcium chloride in desiccators, or in vessels that allowed easy interchange of air of the vessel and the surroundings or in moist chambers. These vessels were transferred to apparatus at the required temperature or in some instances, left on the laboratory desks. At hourly, daily, weekly, or other suitable intervals, slides were taken, drops of water added and left for 24 hours for the conidia to germinate at laboratory temperature. Examination was then made under the microscope.

3. Results.

In the accompanying table, the results are given of not more than three experiments in each series. Under the heading "percentage germination" the highest and lowest are stated, less than 1 per cent. being shown as "trace". As the relative humidity in the desiccators and moist chambers was not determined, the abbreviations "desicc," and "sat," should be interpreted as being in the first instance a very dry, and in the second, a very moist atmosphere. It is obvious that in many cases the number of experiments is not sufficient to enable comparisons to be made between the results obtained in different humidities at given temperatures, especially so because of unaccountable differences in initial viability of various lots of conidia. The results of keeping conidia in dry soil at low temperature may be worthy of note, because many other slides with the same initial percentage of germination stored in the same refrigerator during the same period lost their vitality much more quickly. Whether this difference was due to the conidia themselves or to the influence of storage in soil remains to be determined. From the table it appears that temperatures of about 18°C. or lower are most favorable to longevity.

4. Discussion.

Variation in the percentage of germination of freshly detached conidia is a problem that has occupied our attention for some time. It appears at present difficult, if not impossible, to be able to say with any degree of certainty whether samples taken from day to day will or will not give satisfactory germination. Viability appears to vary with the age of the plant and of the lesion, with the prevailing conditions of temperature and humidity, and with the season of the year. Conidia from seedlings usually give a much larger percentage of germination than others taken from more mature plants growing under the same

TABLE 1.—LONGEVITY OF CONIDIA UNDER GIVEN CONDITIONS.

No. of Experiments.	Temperature.	Relative Humidity.	Maximum Longevity.			% Germination.	Remarks.
			Experiment 1.	Experiment 2.	Experiment 3.		
1	40° C.	Desiccator	1 day	..	..	5%	
1	,,	35%	..	..	..	None	
1	33° C.	..	1 day	..	..	30%	
2	28° C.	Desiccator	4 days	5 days	..	Trace	
1	,,	30–45%	..	..	..	None	No germination at 24 hours or after
2	,,	Sat.	1 day	..	..	5%	
2	24° C.	Desiccator	6 days	None	..	Trace	
2	,,	70–80%	7 days	1 day	..	,,	
2	,,	Sat.	6 days	3 days	..	,,	
4	16–18° C.	Desiccator	11 days	6 days	36 days	Trace	The results of three experiments are given in this table
3	,,	60–70%	4 days	1 day	9 days	20% to trace	
3	,,	Sat.	6 days	5 days	12 days	1% to trace	
3	10–11° C.	70–80%	None	None	12 days	Trace	
6	3–5° C.	Desiccator	7 days	6 days	9 days	50% to trace	Three results are given here
20	,,	60–80%	60 days	49 days	37 days	10% to trace	
1	,,	Sat.	12 days	..	..	1%	
1	Below 0° C.	..	37 days	..	..	7%	Conidia frozen in drops of water on slide
1	3–5° C.	60–80%	60 days	..	..	2%	Conidia on slides in dry soil. This experiment is still in progress

environmental conditions. The same holds true of those from diseased leaves taken from such plants, and kept under moist conditions in the laboratory. In spring and autumn, germination is also very much more satisfactory than during either summer or winter. The most satisfactory experiments on the longevity of conidia have been obtained with those taken from seedlings in the autumn.

The studies on longevity here reported were undertaken to obtain data regarding the probable length of life of conidia under different conditions of temperature and humidity, in order that the knowledge so obtained could be applied to arriving at an explanation of the spread of the disease from infected seed beds to others by means of air-borne conidia or conidia carried by various agencies, including insects, cultivating tools, and man. From the literature, the general idea is gained that conidia of species of the *Peronosporales* generally are short lived, retaining their viability longest under moist conditions. In Whetzel's(5) account of *Peronospora schleideni* on onion, he states that the conidia remained viable for only a few hours. Katterfeld,(3) however, keeping them under moist conditions, found that they remained alive for ten days, but that after two hours exposure to sunshine in a dry atmosphere they were killed. In one experiment, we exposed conidia on slides out of doors at 14° to 17° C. for 24 hours. During this period, they were exposed to direct sunlight for ten hours, after which 2 per cent. germination was obtained, but none after 48 hours. Patel(4) obtained germination of conidia of *P. trifoliorum* after freezing for 173 hours.

As may be seen by reference to the table, conidia from diseased tobacco seedlings remained viable for relatively long periods, not only frozen or under cool, moist conditions, but also desiccated at higher temperature, and when kept in cool, fairly dry soil.

Since under these widely varied conditions they remain viable for days, weeks, and even months, it appears that in nature there may be some environmental conditions that may also allow of long life, and therefore the chances of spread of the disease over larger areas may be much greater than was previously thought possible.

It is therefore obvious that if the downy mildew of tobacco is to be controlled effectively, it will be necessary for all growers in their respective districts to co-operate in ploughing under all plants after the crop is reaped as well as inspecting the fields periodically and destroying surviving plants. In the spring all volunteer plants and diseased seedbeds should be destroyed. Only co-operative effort is likely to succeed.

5. Conclusion.

Conidia of the fungus causing downy mildew of tobacco may remain viable for as long as two months under cool, moist conditions, and for periods as long as five weeks over fused calcium chloride in desiccators.

Their ability to remain viable for such long periods under widely varying conditions emphasizes the necessity for destroying diseased plants after the crop is harvested, as well as wild hosts, volunteer plants, and diseased seedlings.

(3) Katterfeld, N. O., Contribution to the biology of *Peronospora schleideni* Ung. *Morbi Plantarum*, Leningrad, 15 : 2. 71–87, 1926.

(4) Patel, M. K., Studies of *Peronospora trifolicrum* De By. on species of Leguminosae. *Phytopathology* 16 : 72, 1926.

(5) Whetzel, H. H., Onion Blight. New York (Cornell) Expt. Stat. Bull. 218, 139–161, 1904.

The Distribution of Lignin in the Cell Wall of Wood.

By H. E. Dadswell, M.Sc.

For years past, a few investigators have interested themselves in a study of the distribution of the lignin in the walls of the cells of wood as a part of the more general study of the constitution of the cell wall. Information on this last-mentioned point is of fundamental value to a better understanding of the physical and chemical properties of wood, and is also of immediate practical value in connexion with such matters as the production of paper pulp and the preservation of timber by impregnation with preservative solutions.

In ordinary qualitative analyses of wood, the isolation of lignin is accomplished by the treatment of extracted wood powder with 72 per cent. sulphuric acid, by which treatment the cellulose portions of the cells are first greatly swollen and finally dissolved. The lignin is isolated as an amorphous powder. Ritter(1) was the first to apply this treatment to a small block of wood, which was subsequently immersed in paraffin and used in the preparation of thin sections for later examination under the microscope. In this manner, he showed definitely that the middle lamella or cementing layer joining cells to cells was composed of lignin. At the same time, he demonstrated the existence of some lignin which he assumed to be derived from the cell walls. This he termed the "cell wall" lignin.

Harlow(2) in his study of the constituents of the cell wall attempted to check Ritter's results. He treated thin sections of wood with 72 per cent. sulphuric acid on a microscope slide and observed the results of the treatment through the microscope. As a result, he concluded at first that amorphous secondary wall lignin was not distinguishable. However, by the treatment of mildly chlorinated wood with sulphuric acid, he subsequently showed that the secondary walls of softwoods were appreciably lignified, while those of hardwoods, with a few exceptions, contained practically no lignin.

Scarth and his co-workers(3) have studied the structure of the cell wall, by means of solvents, colour reactions, and differential staining. As a result of their work, it is pointed out that in hardwoods lignin appears to be present in decreasing amounts in the middle lamella, tertiary thickening of vessels, thick walled ray cells greater than secondary wall vessels, and fibre tracheids greater than fibres. In softwoods the order appears to be:—Middle lamella greater than ray cells, thick walled epithelial lining of resin canals greater than the secondary walls of tracheids, greater than thin wall epithelium.

The exact distribution and function of the lignin in the cell walls has not been fully investigated. Scarth(3) shows an illustration of a structure visible in walls of spruce swollen by 72 per cent. sulphuric acid, i.e., a lattice arrangement of units of the concentric layers making up the cell wall.* These concentric layers also show a measure of

(1) G. J. Ritter. *Jour. Ind. Eng. Chem.* **17**: 1194. 1925.

(2) W. M. Harlow. Bulletin of the New York State College of Forestry, Syracuse University. Technical Publication No. 24, 1928.

(3) G. W. Scarth, R. D. Gibbs, and J. D. Spier. *Trans. Roy. Soc. Canada.* Section V. Biological Sciences. Third series **23**: II., 269–279. 1929.

* The walls of cells of wood are made up of a number of separate layers (as many as twenty in spruce) wrapped around each other in a concentric manner and thus forming the cylindrical shaped hollow cell.

radial alignment of their elements. He gives no explanation of the possible causes of this radial alignment, which in the illustration is not pronounced.

In view of the importance of a complete knowledge of the structure of the cell wall, it was considered of interest to report here an observation made on the distribution of lignin in the cell wall of *E. marginata* (jarrah—an Australian hardwood). This observation was made during the course of certain experiments on the removal of extraneous material (gums, resins, &c.) prior to the determination of lignin. In these experiments, thin cross sections of jarrah were extracted with benzene-alcohol (2 : 1) and treated on a microscope slide with 72 per cent. sulphuric acid. The results of the treatment were observed through the microscope, and it was shown that the extraneous material remained with the lignin. To complete the reaction, the slide was warmed slightly. Further examination then showed that the cellulose portion of the cell wall had been dissolved, leaving behind the lignin of the cell wall presumably in situ. This lignin was in the form of fine black lines in a definite radial arrangement (see Fig. 1, Plate 4). It was considered possible that this radial arrangement was due in some way to the presence of the extraneous material, but repetition, both under the same conditions and after the section had been treated with N/8 sodium hydroxide for 80 minutes at 98–100° C. in order to remove all extraneous material, still gave the same result.

It was therefore concluded that this radial arrangement had a definite connexion with the distribution of the lignin in the cell wall. It would seem that the function of this lignin is to bind or cement together the numerous fibrillæ of the layers of the cell wall.

It may be suggested that the lignin of the cell wall is in chemical combination with the cellulose, but if this were the case, such a regular arrangement of lignin would not be expected.

Experiments of a similar nature to those outlined above will be carried out with other species of eucalypts at a later date. It is possible that the comparatively thick cell walls encountered in numerous members of this species will provide an excellent field for further micro-chemical experiments on the structure of the cell wall.

PLATE 1

(The Role of Pasture Species in Regions of Winter Rainfall and Summer Drought. See page 140.)

Map showing the approximate boundaries of the Australian grassland zone receiving effective winter rainfall and periodic summer drought (*vide* text).

Rainfall data from Griffith Taylor and H. A. Hunt.]

PLATE 2.

(The Control of Soft Rot (Water Blister) of Pineapples caused by *Thielaviopsis paradoxa*. See page 152.)

FIG. 1.—Growth of *Thielaviopsis paradoxa* on the outside of pineapple.

FIG. 2.—Long section of diseased pineapple showing (*a*) final stage of rot and growth of fungus in lower part. (*b*) Advance of rot between A and B.

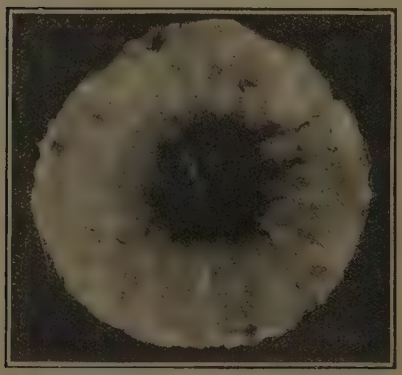

FIG. 3.—Cross section of diseased pineapple showing black growth of fungus in and surrounding the core.

PLATE 3.

(The Apparent Effect of Mallee Scrub in Causing Frosts. See page 173.)

Illustration of typical Mallee Scrub.

PLATE 4.

(The Distribution of Lignin in the Cell Wall of Wood. See page 185.)

Photo-micrograph of a transverse section of jarrah, after treatment with sulphuric acid (of 72 per cent. strength), showing the disposition of the lignin of the cell walls. The acid has removed the cellulose of the cell wall, leaving the lignin of the wall as the dark radially aligned material seen above. × 870.

NOTES.

Proposed Investigations on Insecticides and Fungicides.

At the time of the Imperial Conference held last year, the Empire Marketing Board felt it desirable that advantage should be taken of the presence in London of representatives of oversea scientific organizations to discuss with them the Board's work in the field of scientific research. Accordingly, two meetings were held between the oversea representatives and members of the Board's Research Grants Committee. At those meetings it was agreed that a useful step in the promotion of co-operation could be effected if the Board were to arrange in future to inform, and, where necessary, consult oversea research organizations on particular applications submitted to the Board for grants for research. It was realized that this procedure would not be necessary in all cases, but would apply to those schemes which might have a general Empire significance.

One of the schemes of this nature which was discussed informally at the meetings with oversea representatives was that embodied in the report of the Insecticides and Fungicides Committee of the English Ministry of Agriculture. This Committee was appointed to report on the action required to carry into effect the following resolution of the Imperial Agricultural Research Conference of 1927:—

> "That, in view of the general importance of insecticides and fungicides in the control of diseases and pests, and, in view of the very limited number of substances now available for this purpose, and of their relative inefficiency, this joint meeting of members of the Entomology, Plant Pathology, and Fruit Committees recommends that an investigation of the whole chemical field should be undertaken by chemists working in collaboration with entomologists and plant pathologists."

The report of the Committee, under the chairmanship of Mr. J. C. F. Fryer, O.B.E., M.A., referred to the immense losses which are annually incurred throughout the world by the depredations of pests and by diseases of cultivated crops, and it was pointed out that there is no doubt that, at all events for many years to come, measures involving the use of chemicals to destroy insect pests and parasitic fungi and bacteria, or to prevent their attacks, must remain the most important line of defence. The Committee referred to the fact that, whilst no statistics are available of the total consumption of insecticides and fungicides within the Empire for the purpose of demonstrating the outstanding importance of the subject, some idea might be gained from other considerations. There are, for example, at least 4,000,000 acres of fruit within the Empire; if only one-quarter of this area were sprayed only twice a year, not less than 1,000,000,000 gallons of spray fluids would be used. Taking the average cost of the spray fluids as 1d. per gallon of dilute wash, the expenditure on chemicals for spraying fruit would not be less than £4,000,000 a year, apart from the labour in applying them, and if labour costs are included can hardly be less than £10,000,000. The Committee pointed out that, in view of the immense issues at stake, it is remarkable that up to the present so small an effort has been made to discover substances having valuable fungicidal and insecticidal properties, and to find how these properties can be turned to useful account.

The Committee recommended that, in order to give effect to the terms of the resolution, it is desirable that a central team of workers should be placed at the East Malling Research Station, Kent, and that additional staff should be provided at the Horticultural Research Station, Cambridge, at the Rothamsted Experimental Station, at Long Ashton Research Station, and at the South-Eastern Agricultural College, Wye. The total expenditure for a period of five years would be approximately £46,000.

A copy of the Committee's report has been forwarded to the Council for Scientific and Industrial Research by the Empire Marketing Board with a request to be furnished with the Council's observations, with particular reference to the interest and possible application of the scheme to problems in Australia, and also with any suggestions for linking up the proposed researches with work already undertaken or in progress in Australia. A reply has been sent stating that the Council supports the proposals, and that it will be very glad to do everything in its power to co-operate in the work, and later to arrange, if desired, to test on a large scale those insecticides and fungicides which are likely to be of value. The Empire Marketing Board was also furnished with certain comments by Dr. B. T. Dickson and Dr. R. J. Tillyard, the Chiefs respectively of the Council's Division of Plant Industry and Economic Entomology, and it was advised, among other matters, that it was desirable that close co-operation should be maintained in the matter, not only with the State Departments of Agriculture, but also with such organizations as the Waite Agricultural Research Institute. It is intended to bring the matter before the Council's Standing Committee on Agriculture at its next meeting.

"Nutrition Abstracts and Reviews"—A New Periodical.

One of the problems with which the present-day research worker—and, in fact, any one who is desirous of keeping in the forefront so far as the application of science to his particular industry is concerned—is confronted is the difficulty of becoming conversant with the relevant information contained in all the numerous journals and reports that are published from time to time. The problem is a serious one even in the older and more densely populated countries, where numerous and easily accessible libraries exist. It is still more serious in countries such as Australia, where the distances between research workers and libraries are often great. Moreover, the numerous languages in which scientific information is now published constitutes another important aspect of the problem.

One of the objects of the 1927 Imperial Agricultural Research Conference was to develop machinery for overcoming the problem in so far as it affected the various branches of science which have become more important of late as a result of the intensive application of science to agricultural practices. Considerable progress in this direction has already been made. A recent instance is the decision to publish a new periodical, entitled *Nutrition Abstracts and Reviews.*

This new journal will be issued under the direction of the Imperial Agricultural Bureaux Council, the Medical Research Council, and the Reid Library (of the Rowett Research Institute, Aberdeen). The editors are Dr. J. B. Orr, of the Rowett Research Institute; Professor

J. J. R. Macleod, of the University of Aberdeen; and Dr. Harriette Chick, of the Lister Institute of Preventive Medicine, London. They will also be assisted by corresponding editors in the different countries abroad. Sir Charles Martin, Chief of the Division of Animal Nutrition, C.S.I.R., is a member of the Committee of Management.

The need for the journal is covered in the following extract from a prospectus that has been issued in connexion with it:—

> "In the past few years there have been great developments in our knowledge of nutrition, and in its application to human and veterinary medicine and to animal husbandry. The increasing volume of work now being done in this field appears in a wide range of journals devoted to pure science and to human and veterinary medicine and agriculture. Among the increasing number of research workers and others interested in nutrition there are few who have access to all the publications containing information relating to the subject.
>
> An attempt will be made in this journal to collect abstracts of all papers which have a bearing on problems of nutrition. These abstracts will be made, as far as possible, by workers actively engaged in research."

The branches of the general subject which will be reviewed in the journal include the following:—

(i) Technique.

(ii) Chemistry and properties of foodstuffs.

(iii) Physiology of nutrition, including digestion, absorption, metabolism, and the chemistry of tissues and body fluids, and the relationship of ductless glands and hormones to nutrition.

(iv) Human dietetics.

(v) Feeding of farm animals.

(vi) Diet and health, including deficiency diseases, and immunology, and population and morbidity statistics, in relation to nutrition.

(vii) Therapeutic dietetics, human and animal.

(viii) Food economics.

The journal will also contain reviews, by acknowledged authorities, on the existing state of knowledge of particular subjects. It will be of crown quarto size, and volume 1 will consist of about 600 pages, including the index. For the present, the journal will be published quarterly in January, April, July, and October. The first issue will be in October, 1931, and will be a double number, covering the literature from January to June, 1931. The journal will be printed by the Aberdeen University Press, and will be published by the Imperial Bureau of Animal Nutrition.

The subscription will be £1 per volume, or 6s. 6d. per number. Subscriptions should be sent to the Secretary, Committee of Management, care of the Reid Library, Rowett Research Institute, Aberdeen.

Braxy-like Disease of Sheep in Western Australia.

Brief notes regarding the progress of these investigations which are being carried out in co-operation with the Department of Agriculture of Western Australia were given in previous issues of this *Journal* (Vol. 2, pp. 109, 246, 1929). Since that time, however, the active and predisposing causes of the disease have been definitely established and some methods of control introduced. A full account of the work in Bulletin form will be published at an early date. In the meantime, the following brief notes are of interest.

The disease is an acute and infectious one that affects sheep in Western Australia particularly, although there are indications that the other States of Australia are not entirely free. It is characterized by a fatal termination generally without premonitory symptoms. Animals in good condition are chiefly attacked. Putrefaction after death is rapid. There are, however, no very characteristic post-mortem appearances in fresh carcasses, such changes as are seen being simply the evidences of toxæmia and general poisoning. The most characteristic feature is the presence in the small bowel contents of very large numbers of micro organisms closely allied to, but distinguishable from, *Bacillus Welchii,* and for which the investigator, Mr. H. W. Bennetts, M.V.Sc., has adopted the specific name *Bacillus ovitoxicus.* The disease has a definite seasonal occurrence (April to October), and is confined to cultivated and particularly to well-improved areas. It does not occur on "bush" lands, and the incidence may be checked by transferring affected flocks to uncultivated pastures. Although in many respects similar to, it is quite distinct from, black disease of the eastern States, which is due to an entirely different microbe.

B. ovitoxicus is a microscopic rod-like organism or bacillus which is able to develop spores and thus to persist for long periods in soil, &c. It belongs to the anærobic group, which grow only in the absence of oxygen. Originally considered, on first isolation, to be *B. Welchii* (one of the main causes of gas gangrene in soldiers during the war), highly technical tests have demonstrated that it is really a different organism, and one hitherto undescribed, although closely related to *B. Welchii.*

As an important result of the investigations, a vaccine has been developed for use against the disease. Present indications are that it will prove a valuable one, but as yet an insufficient number of sheep grazing under natural conditions have been treated to enable its efficacy to be guaranteed. However, some 10,000 sheep are being vaccinated during the current season.

Strong evidence has been obtained that the disease, to which the distinctive scientific term "entero-toxæmia" has been given, is due to development of enormous numbers of the causal bacillus in the small intestines of sheep in good condition, and feeding on rich pastures low in fibre content. The bacteria develop a highly poisonous material or toxin which is absorbed into the system. These bacteria, like others of their class, have their normal habitat in rich soils, and under certain circumstances can even be introduced into the alimentary tract of animals without untoward results. It has been found, however, by Mr. Bennetts that any conditions conducive to a slowing down of the movements of the small intestines of sheep (really indigestion), such as easily found rich fodder, lack of exercise, &c., facilitate their multiplication within the bowel, and the consequent elaboration of their particular poison or toxin.

In addition to the use of the vaccine, control measures to be discussed at length in the forthcoming bulletin are the feeding of roughage, the exercise of sheep, the avoidance of close grazing, the careful and immediate disposal of carcasses, prophylactic (laxative) licks, and naturally acquired immunity—all of which have important bearings on the occurrence of the disease.

Although this investigation would appear to have a purely local importance, its significance may prove to have a much wider scope. The group of bacteria to which *B. ovitoxicus* belongs (*B. Welchii*) has universal distribution, and consequently it is unlikely that the activities of this particular member are confined to the western part of the continent. In fact, Dr. L. Bull, of Adelaide, has described a disease almost certainly due to the same organism, and cases of rapid death in sheep hitherto ascribed to other causes (*e.g.*, black disease, pregnancy paralysis, &c.) may turn out to be of the same nature as the so-called braxy-like disease of Western Australia. This question is now receiving the careful attention of the scientific members of the Council's Division of Animal Health.

Worm Parasites of Sheep recently found in Australia.

Oesophagostomum venulosum.—In a previous issue (February, 1931, p. 64), reference was made to the discovery by the Council's Parasitologist (Dr. Clunies Ross) that this parasite existed in Tasmania. At the time he was unaware that the parasite, which morphologically closely resembles the nodule worm of sheep, had previously been reported in Australia. The discovery was accordingly considered a new one. Dr. Ross has now found that a brief reference to the parasite has been made by H. W. Bennetts, M.V.Sc. (the Council's Veterinary Pathologist in Western Australia) to the Royal Society of Western Australia (see its *Journal* **14**: 58, 1928). Since our last issue appeared, Dr. Ross has found the parasite to exist in other parts of the continent.

The Hook Worm of Sheep—Monodontus trichogonocephalus.—In the course of the parasitological investigations in progress at Sydney, Dr. Clunies Ross, and his assistant, Mr. Gordon, B.V.Sc., have recently found their first specimen of the hook worm of sheep—*Monodontus trichogonocephalus*—which the former has long suspected of being present in Australia. For some time they have been closely examining the internal organs of sheep from different parts of the Commonwealth, with a view to determining the parasites present. The worm in question is responsible for serious losses in East Africa, where a carbon tetrachloride treatment has recently been developed against it. As it may possibly become a problem in Australia, efforts are now being made to determine its extent and distribution.

Black Disease of Sheep in Germany.

In view of the amount of attention the Council has recently given to black disease of sheep, and of the development of a simple means of overcoming it*, it is of interest to note that the disease has recently been the subject of some concern in Germany. Investigations carried out in

* Council for Scientific and Industrial Research, Australia, Bulletin 48 (1931).

that country by Mieszner, Meyn, and Schoop have just been reported.† Previously (in 1897), Peters had discussed the disease, stating that it had been known for a decade in Mecklenburg. Subsequently, it has been described in several parts of Germany, especially in the region between East Germany and West Prussia. Even in 1909, Mieszner stressed the importance of working only with freshly dead animals. The latest researches of the authors have demonstrated that the German "Bradsot" is entirely different from the "Northern" form of braxy (Scotland, Iceland, Norway, &c.). In fact, comparing the German disease with the Australian black disease as described in Turner's recent monograph†, the three investigators mentioned above have no doubt whatsoever that the two diseases are identical.

The clinical, post-mortem, histological and bacteriological pictures of the German bradsot and the Australian black disease are the same in all details, even to the presence of young wandering flukes (*F. hepatica*) in the liver. The German authors, however, are not yet convinced that the presence of fluke is anything more than a coincidence; in other words, they do not recognize their essential role in the causation of the disease.

The causal organism, present only in the necrotic areas in the liver in quite fresh cases, behaves just as Turner's strains do. The authors were able to show that, although the organism differs from the type *oedematiens* strains as regards size and several other small details, yet it is immunologically indistinguishable from it. In spite of this finding, however, they prefer to adhere to the name *B. gigas* introduced by Zeisslar before immunity tests had been carried out.

The authors found that it was difficult to immunize guinea pigs satisfactorily against their bacillus by means of sublethal doses of toxin; better results were obtained with anacultures and anatoxins though even here the immunity varied considerably (compare Turner's experience with guinea pigs (A.W.T.)); and serum-culture mixtures were quite unsatisfactory. A field test has been instituted with anacultures, but owing to the non-appearance of the "bradsot," no results are obtainable.

The authors for the present are advising as control measures:—(1) The deliberate lowering of condition of the sheep during the susceptible period since mostly well-nourished animals succumb; and (2) the avoidance of low-lying pastures or the hay grown on such pastures for feeding (surely this points to the influence of fluke cercariae? (A.W.T.)).

Harvard University Scientific Expedition to Australia.

The University of Harvard, Cambridge, Massachusetts, U.S.A., is sending an expedition to Australia to gather entomological, zoological, and ornithological specimens for their Museum of Comparative Zoology. The personnel of the party is as follows:—Professor W. M. Wheeler, Dr. Glover Allen, Dr. P. J. Darlington, Mr. W. E. Sheville, Dr. Ira Dixon, Mr. Ralph Ellis, and Mr. H. Stevens, who will join the party in Australia from Shatong, Sikkim.

One of the principal objects of the expedition is to form friendly relations with the various museums in Australia, to assist them, and to co-operate with Australian scientists. It is understood that the members of the expedition will arrive at Sydney in August.

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† *Zentralbl. f. Bakt.* I. orig. **120**: 257–290, 1931.

The "Journal of Dairy Research."

The Empire Marketing Board has recently asked the Council to assist in making the *Journal of Dairy Research* more widely known throughout Australia. The following information furnished by the Board is accordingly published.—Ed.

The Imperial Agricultural Research Conference of 1927 recommended to the attention of the Empire Marketing Board a proposal for the establishment of a *Journal of Dairy Research,* and one of the first tasks of the Board's Dairy Research Committee, which was set up immediately following the Conference, was to draw up detailed plans for such a journal. The Board agreed to subsidize the journal for an initial period, since it could not be expected to secure, in the first few years, a sufficient income to place its upkeep on a permanent and independent basis. The first number of the journal was issued in November, 1929, and three further numbers have since appeared at half-yearly intervals.

The need for a periodical of this kind was voiced by those who spoke at the Imperial Agricultural Research Conference on behalf of dairy research workers in many parts of the Empire. There was at that time no common medium for the publication of the results of research in this field, records being scattered through a great variety of journals.

The present number of subscribers to the journal is only 190, whereas some 500 are necessary if it is to be made self-supporting. It is, therefore, strongly hoped that increased support for the issue will be forthcoming from all interested in promoting the well-being of the dairy industry throughout the Empire, since it would be unfortunate if the publication, which merits a wider appreciation, had to lapse on account of insufficient support.

The journal is edited by Dr. R. Stenhouse Williams, Director of the National Institute for Research in Dairying, Reading, and he is assisted by overseas correspondents in various Empire countries. It contains three classes of material, namely:—(i) monographs by specialists reviewing the existing state of knowledge in different aspects of dairying; (ii) original contributions to dairy science by workers within the Empire; and (iii) reviews and abstracts of current literature.

A feature of the journal is an attempt to collate the published material on a variety of subjects related to dairy science, such as the influence of the soil and other factors upon the composition of milk and its suitability for the preparation of dairy products; the physiology of milk secretion; the handling of milk; its manufacture into butter, cheese, and other dairy products; the faults which may occur in these; problems of transport and storage; the food values of milk produced under varying conditions or treated in different ways; dairy machinery; and certain aspects of animal diseases affecting the milk supply.

The journal is published by the Cambridge University Press in half-yearly parts of about 100 pages, with plates, two parts constituting a volume. The subscription per volume is 15s. Single numbers are 10s. each. Subscriptions are payable in advance, and may be sent to any bookseller, or to the Cambridge University Press, Fetter-lane, London, E.C.4.

Buffalo Fly Problem—Eastern Boundary of Infestation in Australia.

Dr. Mackerras and Mr. Campbell have now returned from Queensland after having surveyed the eastern boundary of the extent of the buffalo fly infestation in Australia. The former has furnished a report on the observations made, and points out that an alarming spread of the fly into Queensland has taken place since the date of Mr. Campbell's previous survey in 1930. There has been an extension of about 85 miles eastwards during the past wet season, and the fly is approximately 50 miles south and 50 miles east of Burketown (on the Gulf of Carpentaria). The south limits in this region appear probably to have been reached, but the possibilities of spread to the east are not so limited.

The work was considerably facilitated by the fact that three officers of the Queensland Department of Agriculture and Stock, namely, Messrs. Woodhouse, Lewin and Seamer, were deputed by their Department to join the Council's officers. As a result, the combined party was split into two and the ground thus covered much more quickly than otherwise would have been the case. The State Minister for Agriculture and Stock (the Hon. H. F. Walker) was also present, and facilitated many necessary arrangements.

In the preliminary sections of the report, mention is made of several factors having a bearing on the problem. For example, it is characteristic of Gulf bullocks that they "top off" quickly, and lose their condition equally quickly. It is, therefore, necessary to regulate carefully the movement of "fats," and of "stores," (although to a lesser extent) with reference to the rainfall in any particular year. If they are held too long they become unmarketable. Moreover, water and feed on the stock routes may give out quickly, and it is consequently very difficult to devise practical plans for the movement of cattle from any part of the involved area at a time of the year when they might be considered free from fly. As indicative of the flying capabilities of the pest, or of the extent to which it may be carried by winds, it is mentioned in the report that a heavy infestation exists on Mornington Island, a distance of some 20 miles away from the mainland. Ample evidence exists that the fly must have reached the Island per air.

In making the survey, the following procedure was adopted:—(i) All station milkers were bailed up and closely examined; (ii) rarely less than 20 per cent. of the mob was put through a crush and the cattle scrutinized at close quarters; (iii) where a crush was not available likely beasts were thrown; and (iv) when it was possible neither to crush nor to throw cattle, they were closely packed in small yards and moved gently round. A careful selection was always made of the cattle to be examined, the order of preference being bulls, old "stags," old bullocks (pikers), bullocks in poor condition, and old cows, this being the relative order of attractiveness to the fly.

The report discusses at length the advantages and disadvantages of (i) the possible establishment of a buffer area; (ii) the establishment of a meatworks at Burketown or Normanton; and (iii) the establishment of a spraying race at the railhead, and the removal of store cattle by selected routes.

The general conclusion drawn is that nothing short of a buffer area offers any hope of stopping the progress of the fly, but that even a buffer area of considerable width offers no certainty of doing so. Dr. Mackerras points out, too, that the danger of dispersal by rail can be met either by a buffer area or by spraying stock at trucking, but that the complete success of either method cannot be guaranteed.

The Degree of Seasoning of Furniture and other Timbers in Relation to Locality—an Australian Survey.

One of the annoyances which few householders escape in a country of such long distances and consequent varying climates as Australia is that caused by the jambing or gaping of doors, drawers and windows, and the cracking or warping of expensive furniture. The cause of these troubles is well known to be due to the timber and to its property of absorbing moisture and swelling when the atmosphere is damp, and losing water and shrinking when the atmosphere is dry. Material that is perfectly seasoned for use in a comparatively cold and moist climate will obviously lose some of its moisture and shrink when taken to a warmer or drier locality. The reverse, of course, is also true when timber from a warm and dry locality is taken to wetter places. The trouble could be largely overcome if the amount of moisture timber contains when perfectly seasoned for each particular locality were known. This equilibrium moisture content will depend to a very large extent upon the climate; for instance, at Adelaide it might be 3 per cent. or 4 per cent. lower than at Hobart. It may also depend on the timber.

The Division of Forest Products is accordingly commencing a moisture equilibrium survey throughout Australia with a view to determining:—

(i) The variation in moisture content of different species of timber in summer and winter;

(ii) the effect of different thicknesses of wood and of paints and varnishes on the extent of this variation;

(iii) how the extent of variations change with indoor as against outdoor conditions (under cover); and

(iv) to what average moisture content timbers should be dried for different localities so that they will be midway between the highest moisture content of winter and lowest moisture content of summer, and thus ensure the minimum of movement.

The localities for the tests will comprise the main centres of population of each State, namely, the capital cities. At each capital one timber will be tested, and that will be a common species produced in the State. In addition, at the Division's headquarters at Melbourne, there will be a test of every timber for a comparison of species with species. Certain special tests will also be made on the effect of thickness and of paint and varnish coatings. Extreme care has been taken in the selection of material for the survey. To ensure representative samples, light, medium, and dense qualities of well seasoned boards of each timber have as far as possible been selected, and the boards used have been cut both on the back and the quarter. For the major portion of the survey, sample boards have been prepared 12 inches long and 6 inches wide and ¾-inch thick. To ensure that these short pieces will be representative of full length boards from the point of view of behaviour on exposure, their ends have been coated with a specially prepared paint, made up largely of aluminium, and having a high resistance to moisture transmission. In this way, the drying out of the short pieces from the ends will be prevented.

During the preparation of the test pieces, moisture content determinations were made at both ends of the boards, and the latter were then weighed so that by further weighing at intervals it will be possible to follow the variations in moisture content from time to time. Dimension lines have also been carefully drawn across the widths of samples so that the extent of shrinkage and swelling can be determined. Density measurements have been made to indicate the quality of the material under test.

The survey is being carried out with the co-operation of the Forests Departments of Western Australia and Queensland, the Universities of Adelaide and Tasmania, the Australian Forestry School at Canberra, and the Sydney Technological Museum. The duration of this preliminary survey will probably be about two years. The timbers to be used are:—Jarrah (*E. marginata*)—Western Australia, *Pinus radiata*—South Australia, brown top stringybark (*E. obliqua*)—Tasmania, mountain ash (*E. regnans*)—Victoria, tallowwood (*E. microcorys*)—New South Wales, alpine ash (*E. gigantea*)—Federal Capital Territory, and hoop pine (*A. cunninghamii*)—Queensland.

Freshwater Biological Research.

The Freshwater Biological Association of the British Empire has applied to the Empire Marketing Board for a grant towards the establishment and maintenance of a Freshwater Biological Research Station on Lake Windermere at an estimated cost of from £700 to £800 per annum. Professor F. E. Fritsch, Chairman of the Council of the Freshwater Biological Association of the British Empire, has reported that the work of the proposed station cannot fail to help in the solution of problems arising in relation to the important fisheries in the great lakes of Central Africa and other parts of the Dominions and Colonies. How little is known with respect to the biology of tropical waters is shown by the case of an important food-fish of Lake Victoria that was even unknown to science until the lake in question was visited by a recent expedition.

The control of the insects that are the carriers of human disease in many parts of the Empire is largely a question of aquatic biology, since a considerable number of them breed in freshwaters, and often only in waters of quite a different type. This matter is now being widely studied in many parts of the Empire, but without a better understanding of the fundamental facts of freshwater biology a proper solution is not likely to be attained. It is with the elucidation of these fundamental facts that the projected Freshwater Biological Station will be occupied, and it is claimed that the results of its investigation will be of wide value in many parts of the Empire.

Sufficient funds for the maintenance of the station in 1931 have already been obtained, and the Empire Marketing Board has decided to defer consideration of the matter until the station has been established and a clearer impression formed of its needs and potentialities.

Australian Insects for the United States—Visit of Mr. S. Flanders.

At the present time, Mr. Stanley Flanders, Parasite Collector of the University of California, Riverside Citrus Experiment Station, is in Australia, and is making his headquarters at the Entomological Division of the Department of Agriculture, New South Wales.

His object in visiting Australia is to try to locate the native habitat of the citricola scale (*Coccus pseudomagnoliarum* Kuwana), an insect considered to be indigneous to hot, dry climates, such as exist in the interior of New South Wales, Queensland, Northern China, &c. The principal host of this scale in the dry sections of Southern California is citrus, and for this reason it is possible that the wild species of citrus in these areas may be the original hosts. In western New South Wales and Queensland, the species *Eremocitrus glauca* (desert lime) is suspected as a possible host, and Mr. Flanders has recently travelled by car as far as Broken Hill and Bourke in his search for this plant. Apparently, the southern limit is the 32nd parallel of latitude. A number of interesting insects were found on it, but so far no soft scales of the sub-family Lecaniinæ, to which group the citrocola scale belongs. Mr. Flanders has recently visited Canberra and seen the work of the Council's Division of Economic Entomology. While there, he gave an interesting lecture to the staff of the Division on the problem of control of codlin moth by *Trichogramma,* on which he worked for some years. Mr. Flanders intends to visit the areas in which the desert lime is found in Queensland and Northern New South Wales. Once the scale is discovered, its parasites will be studied and determined, and shipments of all the primary species sent across to California. Northern China appears to be the most promising region for discovering the scale, but Australia must be eliminated first. Mr. Flanders has already shipped a number of beneficial parasites of mealy bugs, black scale and red scale of citrus, which will make the visit of material benefit to the citrus industry of Southern California, even though the parasites of the citricola scale are not secured.

Mr. Flanders would be glad to hear from anybody having knowledge of the localities where desert lime can be found in Queensland and New South Wales.

"Plant Breeding Abstracts."

The Imperial Bureau of Plant Genetics has begun to issue a publication entitled *Plant Breeding Abstracts,* in which all the more important current publications dealing with plant breeding and the genetics of crop plants are listed. The references are classified according to subject, and each reference is followed by an abstract indicating the subject matter of the paper and the results obtained. The papers are divided into two halves—those published in the British Empire, and those published in foreign countries. Papers written in foreign languages are usually abstracted somewhat more fully than papers in English.

Plant Breeding Abstracts is issued quarterly, and Vol. I., No. 3, which was published on the 1st April, 1931, contains 197 references covering 52 pages.

The annual subscription for the publication is at present 5s. post free, single copies being obtained at the price of 1s. 6d. Subscriptions should be sent to the Deputy Director, Imperial Bureau of Plant Genetics, School of Agriculture, Cambridge, England.

Recent Publications of the Council.

Since the last issue of the *Journal*, the following bulletins and pamphlets have been published:—

Bulletin No. 47—Radio Research Board, No. 1, Paper No. 1—"Corrections to Field Strength Measurements with Loop Antennae," by W. G. Baker, B.Sc., B.E.; Paper No. 2—"A Radio Field Strength Survey within 100 miles of Sydney," by W. G. Baker, B.Sc., B.E., and O. O. Pulley, B.Sc., B.E.

Paper No. 1 discusses the theory of the loop antenna on the assumption of uniformly-distributed capacity. It is shown that, in measuring loop resistances by the added-resistance method, different results are obtained by adding the resistance at the centre or at the end of the loop.

In Paper No. 2 the development of a set capable of measuring weak field strengths is described. The main part of the paper, however, is devoted to the results of a survey of the distribution of field strengths for, roughly, 100 miles around Sydney, measurements being taken of the strengths from the larger broadcasting stations in that city. A map is given showing the distribution of field strengths for station 2FC and station 2BL. In this, the dampening effect of wooded mountains is clearly shown.

Bulletin No. 48—"The Experimental Error of the Yield from Small Plots of Natural Pasture," by J. Griffith Davies, B.Sc., Ph.D.

This Bulletin deals with investigations being carried out by the Waite Agricultural Research Institute as a co-operative enterprise between the Institute, the Empire Marketing Board, and the Council for Scientific and Industrial Research. The publication is of interest chiefly to agrostologists, as it discusses for the first time the magnitude of the experimental error attached to varying plot sizes of pasture.

Bulletin No. 49—"Factors Affecting the Mineral Content of Pastures, with Particular Reference to the Environmental Conditions Incidental to Southern Australia," by Professor A. E. V. Richardson, M.A., D.Sc.; H. C. Trumble, M.Agr.Sc., and R. E. Shapter, A.A.C.I.

Like the previous number, this Bulletin deals with the co-operative investigations at the Waite Institute. It contains information of considerable value in connexion with pasture management in Australia. The factors affecting the mineral and nitrogen contents of pasture plants have been investigated, with special reference to a region of winter rainfall and summer drought. Pure species grown under similar soil conditions in controlled pot cultures and harvested at a definite stage of growth (flowering) showed wide differences in mineral and nitrogen content, relative yielding capacity, mineral assimilation in relation to transpiration, and absorption of phosphorus from insoluble phosphate. It is shown that it is possible to increase the yields from natural pasture in an area of winter rainfall and summer drought, to lengthen the period over which feed is produced, and to increase the mineral and protein supply in the pasture, by the establishment of superior species (and strains) of pasture plants. In the species *Lolium* and *Trifolium*, the percentage of nitrogen, phosphoric acid, potash, and, to a lesser extent, calcium and magnesium, falls rapidly from the early tillering stage to maturity. Further, the amounts of nitrogen, phosphoric acid, and potash, absorbed per unit of water used by the plant, are particularly high during the initial periods of growth, and fall to negligible quantities towards maturity.

Considerable attention was given to the effects of superphosphate dressings. It was found that the application of soluble phosphate does not materially affect the phosphorus content of plants grown on fertile soil, but that, on the other hand, dressings of superphosphate on phosphate-deficient soils increase the phosphorus content of the herbage to a value comparable with that of a phosphate-rich soil.

The general conclusion is drawn that under the environmental conditions incidental to southern Australia, where alternating periods of winter rainfall and summer drought prevail, it is possible to increase considerably the supply of minerals in pastures, and thus to increase the output of grazing animals, by the use of three interdependent principles—(i) the establishment of persistent species (and strains) capable of assimilating adequate nutrients over an extended period of the year; (ii) the efficient utilization of herbage by means of satisfactory systems of management; and (iii) the maintenance of soil fertility at a sufficiently high level by the application of suitable fertilizers to soils deficient in essential minerals.

Bulletin No. 50—"The Poisonous Action of Ingested Saponins," by Alfred J. Ewart, D.Sc., Ph.D., F.L.S., F.R.S., Professor of Plant Physiology, University of Melbourne.

This Bulletin has a direct bearing on the problem of Kimberley horse disease, a report on which was published by the Council in 1928 as its Bulletin 36. In this earlier publication, results of an investigation carried out by Professor Ewart and Mr. Murnane in the north-west of Western Australia were outlined. Since his return from that locality, Professor Ewart has conducted some further work on the saponin content of various plants. He considers that Kimberley horse disease is due to the ingestion of saponins. In Bulletin No. 50, evidence is given suggesting that certain diseases of stock in various parts of the world are due to the ingestion of plants containing active saponins. In particular, he mentions the following such diseases:—"Walkabout" of horses in North-west Australia, "grub in the head" of sheep in North America, "Winton disease" of New Zealand, Molteno disease of South Africa, and dunsiekte disease of horses in South Africa.

Pamphlet No. 19—"Black Disease: A Short Description of its Nature and Means of Prevention," by A. W. Turner, D.V.Sc.

A short, popular account of the work on black disease of sheep, reported in detail in the Council's Bulletin No. 46, is given. Information is also furnished regarding the nature of black disease and how to determine its presence. In the later sections, the known methods of prevention, namely, the eradication of fluke, the vaccination of exposed sheep, and the disposal of carcasses, are discussed.

Pamphlet No. 20—"The Identification of Wood by Chemical Means." Part I. (Division of Forest Products—Technical Paper No 1), by H. E. Dadswell, M.Sc.

This Pamphlet discusses a possible means of distinguishing between Australian eucalypt timbers by simple chemical methods. In the foreword, the Chief of the Division of Forest Products (Mr. I. H. Boas) points out that the identification of the species from which commercial timbers are derived is of the utmost economic importance; yet, in so far as Australian timbers are concerned, this identification is most difficult once the logs have been cut. The publication discusses the various methods, such as the examination of aqueous and alcoholic

extracts, the burning splinter test, the alkalinity of the ash, &c. Karri and jarrah have been separated by chemical means, namely, on the basis of differences in the cellulose content and in the alkalinity of their ash. Tallowwood, blackbutt, and white mahogany have been separated on the basis of the alkalinity of the ash, together with the behaviour of alcoholic extracts on dilution with water. A simple test has been developed for the separation of redbox and redgum by adding a dilute solution (1 per cent.) of caustic soda to the alcoholic extracts of the timbers. With redgum a chocolate precipitate is formed, while with redbox a yellow precipitate is formed. Chemical methods are also being extended to a distinction between trees of the Ironbark group.

Pamphlet No. 21—"The Density of Australian Timbers: A Preliminary Survey (Division of Forest Products—Technical Paper No. 2), by H. E. Dadswell, M.Sc.

After a discussion of the importance of accurate density determinations for the identification of timbers, it is pointed out that the present methods of measuring the density of wood are unsatisfactory, as the figures obtained by their use vary over a wide range from sample to sample of the one species. A new method for the determination of this quantity is then described. This method involves the determination of (i) the oven-dry weight; and (ii) the volume of the sample after soaking. The results thus obtained are used in the calculation of density figures. From the experiments carried out it has been concluded that soaking under water for five or six days is sufficient to restore the small samples used to their green dimensions, and this has been found to be the case even with dried and collapsed samples. The possibilities of the method for general indentification purposes have been briefly studied in relation to the determination of a number of samples from different species of wood.

Forthcoming Publications of the Council.

The following publications of the Council are now in the press:—

Bulletin No. —"A Soil Survey of the Lower Murray River Swamps," by J. K. Taylor, B.A., M.Sc., and H. G. Poole, M.Sc.

Bulletin No. —"The Soils of Australia in Relation to Vegetation and Climate," by J. A. Prescott, M.Sc.

Pamphlet No. —"The Chemistry of Australian Timbers. Part I. The Study of the Lignin Determination," by W. E. Cohen, B.Sc., and H. E. Dadswell, M.Sc.

H. J. GREEN,
GOVERNMENT PRINTER,
MELBOURNE